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†Fossil

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Dyslexia: Symptoms and Remediation Results

Anita N. Griffiths

The description and remediation of reading difficulties in children has been complicated by a multiplicity of symptoms associated with a condition defined as "dyslexia", "specific dyslexia", or simply "learning disability". The data presented here were originally given at the Florida Psychological Society's 23rd annual meeting in Miami Beach, Florida on May 1, 1970. They represent the results of testing 32 children (24 boys and eight girls) who entered private clinics (Byron Harless and Associates, Tampa, Florida and Griffiths Inc., Lakeland, Florida) because of reading difficulties, often associated with emotional and behavioral difficulties. These results are compared with data from other studies in a manner to more specifically identify a specific reading problem which may be called "dyslexia". The results or remedial treatment for 28 of the 32 children are also discussed.

Benton (1968) defined dyslexia as "a selective retardation of reading skills, resulting in an observable gap between a child's progress in reading and his progress in other areas of learning. This implies a normal or even above normal I.Q." Kline (1968) stated that dyslexia "refers to patients with severe reading disabilities." Pannbacker (1968) uses the concept "a discrepancy between apparent capacity for learning, verbal or nonverbal, and actual level of achievement" when defining learning disabilities.

Benton (1968) associated dyslexia with eye dominance, control and convergence, but suggested ten symptoms which are often noted for children having this condition. These included, among others, hyperactivity, behavior problems, mixed laterality, and poor identification of body parts.

Kline (1968) would eliminate neurologically damaged or per-

ceptually handicapped children from the dyslexic definition, but does associate mixed laterality, poor coordination, and emotional problems with dyslexia. Pannbacker's (1968) associated characteristics were very similar to those of Benton.

Methodology

The Wechsler Intelligence Scale for Children, Frostig Developmental Test of Visual Perception, Gilmore Oral Reading Test, and the Harris Test of Laterality were used as diagnostic tools. In addition to the formalized testing, a family history was taken and certain notations were made concerning unlearned laterality. The author is indebted to Dr. Lorain Hite of Byron Harless and Associates for statistical analyses. Twenty one of the 24 boys and seven of the eight girls entered a three month remedial program. Except for four girls and three boys who were seen only 10 or 11 times, all others completed 12 individual remedial sessions.

All sessions were once a week on a one-to-one basis between the author and the individual child, and each hour represented approximately 50 minutes of actual working time. Specific techniques varied from child to child, depending upon individual needs, and upon which procedure appeared to be gaining the most profitable response. The remedial work may be categorized as working with materials which were intrinsically interesting to the children. Although the learning experiences were challenging, they were planned so that the child could feel successful. Competition was eliminated. Although the children had entered the remedial program because of reading difficulties, standard teaching techniques involving phonics, workbooks, and the structured situation of the conventional classroom in which the child had failed, were completely eliminated, and an atmosphere creating trust and value in the child as an human being was established, both through verbal and nonverbal communication. The parents, the teacher, and the child were all apprised of the situation. An attempt was made to explain what had caused the child to behave in the manner which had produced his problems, and hope was held forth that improvement would be made. During the course of the remedial work, about one-half of the children were placed on Ritalin (methylphenidate hydrochloride) by their referring physician, with apparently beneficial effects. The use of ordinary tranquilizers or

sedatives, which had been tried for some hyperactive children, generally resulted in adverse behavior.

At the conclusion of the remedial work the children were again tested with a WISC, The Frostig Test of Visual Perception, and The Gilmore Test for Oral Reading. For the first two tests, the identical form was used in post-testing and it is recognized that there is a possibility of some contamination when the two tests are given within a three months period. In the case of the Gilmore, Form A was given as the pre-remedial test, and Form B was used for the post-remedial testing, so that contamination does not exist insofar as reading improvement could be measured by this test.

The ages of the children at the time they were first seen varied from 6 years and 1 month to 15 years and 9 months with an average age of 9 years and 5 months.

RESULTS OF WISC TESTS

The WISC tests were given to all children. Verbal I.Q.'s varied between 86-137 with an average of 111; Performance I.Q.'s varied between 75-125 with an average of 104; and Full Scale I.Q.'s varied between 79-133 with an average of 108. Three of the children had I.Q.'s (Full Scale) below 90. In Table 1 the average scale scores with standard deviations from this study are compared with those of Wechsler (1949) and Sabatino (1968).

It will be noted that the 200 children presented by Wechsler with a chronological age of 10 years, 6 months had average scale scores that were almost identical from sub-test to sub-test, whereas, there was considerable variation both in this study, and in that reported by Sabatino. Sabatino's children were forty-five boys, aged 6 years and 4 months to 12 years and 2 months, who were failing in either arithmetic or in reading. Sabatino did not define these children as dyslexic, but as individuals with learning disabilities. However, it will be noted that the average scale scores of Sabatino, while lower, were related to each other in much the same manner as were those in the present study. Object Assembly and Coding were exceptions to this pattern.

In the present study, the Coding sub-test had a high standard deviation and was significantly correlated with the Verbal rather than Performance sub-tests, but Sabatino did not find this relationship. The significance of this is impossible to interpret at this time.

TABLE 1

Comparison of WISC scores with Sabatino and Wechsler

	Wechsler 10½		Griffiths		Sabatino	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Information	9.9	2.9	10.4	2.8	9.0	2.0
Comprehension	10.1	3.1	13.9	3.7	10.4	2.3
Arithmetic	10.2	3.1	9.8	3.1	8.1	2.3
Similarities	10.0	3.1	13.3	3.4	11.1	3.3
Vocabulary	10.1	3.1	12.6	3.3	10.5	3.3
Digit Span	10.0	2.9	10.7	3.0	9.1	2.4
Verbal I.Q.	100.0		111.7		97.0*	
Picture Completion	10.0	3.0	11.3	2.8	10.6	2.2
Picture Arrangement	9.9	3.1	10.2	2.4	9.5	2.3
Block Design	10.1	3.0	10.5	2.5	9.9	2.9
Object Assembly	10.1	2.9	9.2	3.8	10.1	3.3
Coding	10.0	3.1	10.1	4.1	8.2	3.0
Performance I.Q.	100.0		103.5		97.0*	
Full Scale I.Q.	100.0		108.4		97.0*	

*Calculated from mean.

When more individual scores can be factor analyzed, some conclusions concerning the status of Coding and its interpretation for children with learning difficulties may become apparent.

Sixty-eight per cent of those tested had a Verbal I.Q. higher than Performance, and when males were compared with females, 67 per cent of the males and 75 per cent of the females had a higher Verbal I.Q. However, when children were separated by age, 54 per cent of those older than 9 years had a higher Verbal I.Q., whereas, of those 9 years and younger, 74 per cent had a higher Verbal than Performance I.Q.

Correlations were run between all of the sub-tests, and these correlations were compared with those of Sabatino, and with the average population at age 10½ presented by Wechsler.

As contrasted with Wechsler where all sub-tests were significantly correlated, the present study and that of Sabatino showed that most Verbal sub-tests were correlated with each other, but rarely with any Performance sub-tests. Performance sub-tests were

significantly correlated in only two instances in each of these studies. The failure to find significant correlations for the two groups of children with learning disabilities when compared with those for Wechsler's normal population, and the variability in sub-test scores for the two studies are suggestive that the WISC alone offers an early opportunity to identify a possible learning disability.

For the children tested here, an analysis of scale scores for individual children suggest patterns which may be helpful in identifying a specific syndrome. Comprehension had the highest average scale score, and it was the highest Verbal sub-test for 50 per cent of all children. Seventy one per cent of the boys and 63 per cent of the girls had Comprehension scale scores at least two points higher than for either Arithmetic or Information. This discrepancy appeared to become exaggerated with age. Both Similarities and Vocabulary had high average scale scores, but no specific pattern was discernible. Both had highly significant negative correlations with age; Similarities showed significant correlation with all Frostig sub-tests except "position in space"; and Vocabulary was significantly correlated with only the Frostig sub-test "spatial relations".

Of the five performance sub-tests, Picture Completion had the highest scale score for 46 per cent of the boys and 37 per cent of the girls, but there were no real patterns which emerged. As noted above Coding appeared to be related to Verbal sub-tests and Verbal I.Q. rather than to other Performance sub-tests.

A considerable variation in sub-test scores, a high Comprehension score as compared with Information and Arithmetic (particularly if the child is more than 7½ years old), and possibly a high Picture Completion score as compared with other Performance subtests combine to suggest that the child with such characteristics will be reading below his intelligence capability.

RESULTS OF FROSTIG TESTS

The Frostig Test of Developmental Perception was given to all children. Because of the fact that it measures characteristics only to an age equivalent of approximately 9 years and since 15 of the children in this study were older than 9, problems of interpretation were encountered. However, in the 160 instances where chronological age suggested opportunities to score on a sub-test at the Frostig

TABLE 2

Results from Frostig developmental test

Frostig Test	Age Equivalents in Months					
	All Children			Younger than 122 months		
	All	Female	Male	All	Female	Male
Eye Motor Coordination	90	93	88	79	85	76
Figure Ground	86	84	87	83	76	86
Form Constancy	75	74	76	68	67	69
Position in Space	87	80	90	82	77	84
Spatial Relations	85	88	94	88	82	91
Chronological Age	115	113	116	95	94	96
Number of Children	32	8	24	21	6	15

maximum, only 27 such instances occurred. Table 2 shows the average (arithmetic mean) age-equivalents in months for all children and also separates out the 21 children younger than 122 months. These children all scored well below their chronological age level. They averaged lower on "form constancy" than any other sub-test. The "eye-motor" sub-test results were significantly correlated only with "spatial relations", whereas the other four sub-tests were all significantly correlated with each other.

When males were separated from females, test score results suggested sex differences, particularly for the 21 children younger than 122 months. These low scores, when compared with chronological age, appear to be typical of children with reading problems due to visual perceptual difficulties.

RESULTS OF GILMORE ORAL READING TEST

The Gilmore Oral Reading Test was given to all the children, and results from this are compared with the Frostig and with the WISC I.Q.'s on a comparable basis. This basis was arrived at by dividing the age-equivalent on the Frostig by the chronological age; and on the Gilmore by converting grade to age equivalent by adding 65 months to the grade equivalent and dividing by the chronological age. The approximate average age of children as they enter the first grade in Florida is 65 months. Table 3 indicates that scores on both the Gilmore and the Frostig were low in comparison with the I.Q. of the individual children.

TABLE 3

Comparison of Frostig, Gilmore and WISC results

Test Quotient	All	Female	Male
Frostig: Age Equiv./Age			
Eye Motor Coordination	79	85	77
Figure Ground	78	78	79
Form Constancy	68	71	66
Position in Space	79	77	79
Spatial Relations	84	83	85
Gilmore: Grade Equiv./Age			
Accuracy	87	94	85
Comprehension	93	100	91
WISC: I.Q.			
Verbal	112	111	112
Performance	104	104	104
Full Scale	108	108	108

OBSERVATIONS ON LATERALITY AND ORIENTATION

Left handedness, ambidexterity, mixed-laterality for hand or foot, and particularly problems concerned with focusing eye, dominate eye, and lack of eye convergence have been so often associated with reading difficulties that a review of references is not included here.

In the present study, the Harris Test of Lateral Dominance was administered to all children. In addition to this, Unlearned Laterality tests worked out by the author were also given. There was an extremely high proportion of apparent mixed laterality. On the Harris tests, approximately 70 per cent showed mixed laterality for tasks performed with hands or feet. When testing the focusing eye, 25 per cent were mixed, 25 per cent were left-eyed and 50 percent were right-eyed.

The tests concerned with knowledge of left and right did show that about 75 per cent of the subjects were confused. Those that were not confused were all 9½ years of age or older. Twenty-two per cent of the children preferred the left hand. This study suggests that mixed laterality or left-handedness may well be associated with a reading difficulty, but what the association means and how it compares to a normal population of normal readers is unknown and requires additional study.

All of the children showed a poor sense of orientation. This was demonstrated by an occasional tendency to go out the wrong door, by having little knowledge of direction, by becoming lost if sent on an errand, or, in some instances, by getting lost in going from one room to another.

OBSERVATIONS ON HYPERACTIVITY

Approximately 85 per cent of the children were definitely hyperactive or had been so. This was characterized by an inability to sit still, movement of hands or feet, the necessity for getting up and moving around the room, and the need to be continually on the move, with usually a relatively short attention span. Some of the older children who did not exhibit hyperactivity at the time of this study were found to have been hyperactive when they were younger and were so categorized. Five children apparently did not have a history of hyperactivity, but these were all 11 years and older, and whether they had simply learned to compensate for hyperactivity or whether they never had it could not be positively determined by questioning of the parents.

Approximately 85 per cent were considered to be behavior problems in school and at home. The behavior problems were primarily associated with their hyperactivity, and with the fact that they were failing to make proper progress, particularly in reading. They were reacting in a hostile manner to punishment and to the admonitions of their teachers and parents that they were not trying hard enough.

Four of the children appeared to be definitely withdrawn, and are here considered to be behavior problems because of the withdrawal tendencies. These were all children of 11 years of age and older. None of the four were exhibiting hyperactivity symptoms at the time of this study. One of these children had a full scale I.Q. of 79, one of 88, and the other two were 123 and 120. The withdrawal symptoms would appear to be associated with their inability to maintain proper learning performance in competition with the peer group.

RESULTS OF REMEDIAL TREATMENT

The results reported here indicate very marked improvement for all children, and it is recognized that such rapid improvement

has not been reported in the literature. Kline (1968) reporting on treatment of dyslexics in a clinic in Wisconsin, suggested that, "A multi-sensory approach, built upon a good basic phonics program is essential to the successful remediation of specific dyslexia. It is necessary to work on a one-to-one basis and the child should be four or five times a week in a one-hour session." Their remedial program extended over a period of approximately one year. Forty-six of the 50 patients who completed therapy showed significant improvement, and they were seen from 21 to 191 times. Of those who did not improve, all had been removed from the program, prematurely.

Reinmuth (1969), in a general discussion of dyslexia, strongly suggests that the child's behavior problems and his negative self-concept can be alleviated in numerous ways, and that since no specific method of treatment is necessarily good for all, various approaches must be made if improvement is to be obtained. The evident need for different approaches in the present study very

TABLE 4

Comparison of WISC Verbal Scores for 21 boys and 7 Girls before and after 3 months of remedial work

Sex		Information	Comprehension	Arithmetic	Similarities	Vocabulary	Digit Span	Verbal I.Q.	Full Scale I.Q.	Age in Months
Male	Pre	9.5	13.7	9.3	12.5	12.1	10.5	108.3	105.3	120.3
	Post	11.0	17.1	10.5	15.1	13.3	11.0	119.3	120.1	123.3
	Gain	+1.5	+3.4	+1.2	+2.6	+1.2	+0.5	+11.0	+14.8	+3.0
Female	Pre	10.9	13.6	9.0	14.0	12.3	11.0	108.4	106.1	103.1
	Post	11.1	16.9	8.7	16.3	14.3	12.0	118.9	120.4	106.1
	Gain	+0.2	+3.3	−0.3	+2.3	+2.0	+1.0	+10.5	+14.3	+3.0
All	Pre	9.9	13.7	9.2	12.9	12.1	10.6	108.4	105.5	116.0
	Post	11.0	17.0	10.1	15.4	13.5	11.2	119.2	120.2	119.0
	Gain	+1.1	+3.3	+0.9	+2.5	+1.4	+0.6	+10.8	+14.7	+3.0

strongly indicates the validity of this hypothesis. While children may be categorized and grouped together, for some traits, information is still insufficient to be certain that an individual child may be

TABLE 5

Comparison of WISC Performance Scale Scores for 21 boys and 7 girls before and after 3 months of remedial work

Sex		Picture Completion	Picture Arrangement	Block Design	Object Assembly	Coding	Performance I.Q.	Full Scale I.Q.	Age in Months
Male	Pre	11.0	9.9	10.9	9.9	9.4	100.8	105.3	120.3
	Post	14.4	11.7	12.5	13.4	10.8	117.6	120.1	123.3
	Gain	+3.4	+1.8	+1.6	+3.5	+1.4	+16.8	+14.8	+3.0
Female	Pre	11.6	10.7	10.0	9.3	10.9	102.1	106.1	103.1
	Post	13.7	11.7	11.9	12.1	11.9	115.9	120.4	106.1
	Gain	+2.1	+1.0	+1.9	+2.8	+1.0	+13.8	+14.3	+3.0
All	Pre	11.2	10.1	10.7	9.7	9.8	101.1	105.5	116.0
	Post	14.2	11.7	12.3	13.1	11.0	117.2	120.2	119.0
	Gain	+3.0	+1.6	+1.6	+3.4	+1.2	+16.1	+14.7	+3.0

diagnosed, and then treated in a specific or rigid manner. Remedial work and treatment must be tailored to fit the individual child and his difficulties.

Tables 4 and 5 separate the boys from the girls, and then combine the two groups to show the average scale scores on the WISC for each of the sub-tests before and after treatment and the differences that resulted. The average ages at the beginning and ending of the treatment period are also shown in months, and, of course, represent a three month period. Statistical analyses run on these data indicated that there was a significant improvement in I.Q.'s for the group, and that there was no sex difference. Four of the seven girls did not complete 12 sessions, and of these two of the four were materially lower than the others in average improvement. The results between the girls and boys appeared to be very comparable. The greatest increase in sub-test scores was found on Comprehension for both girls and boys, and this was the test upon which they had the highest scale score in the pretreatment testing. Only on the Arithmetic subtest did either sex show an average de-

crease. This was true only for the girls, and was true because one child changed from a scale score of 14 to 8. This child was seen 12 times initially, and she had relatively severe reading and behavioral difficulties at the beginning of the treatment. For both sexes, Arithmetic did not improve at a rate comparable to the improvement on the other sub-tests, and, on the average, Digit Span had an even lower increase. In only 15 of 308 Verbal sub-tests recorded were the post-remedial scale scores lower than the pre-remedial ones.

Performance I.Q. increased to a greater extent than did Verbal I.Q. In the case of Full Scale I.Q.'s, there was an improvement of roughly 15 points for the entire group. Only four children, three boys and one girl, had increases in Full Scale I.Q. of less than five, and all showed an increase of at least three points. None of the children showed a decrease on Verbal I.Q., but on Performance I.Q., one boy and one girl showed a slight decrease and one boy remained at identically the same score. This suggests that these children do differ, and that the difference is perhaps even greater in the area of Performance than in Verbal abilities.

Since the children were brought to the clinic primarily because of a reading problem, the Gilmore reading tests are probably the best measure of the remedial results obtained. Table 6 shows the average grade equivalents for the boys and girls and for the entire group before and after a remedial treatment period of three months. Since three months is approximately one-third of a school year, an average increase would normally have been expected to be one-third of a year or 0.33; however, the average gain on Accuracy was

TABLE 6

Comparison of average grade equivalents for 21 boys and 7 girls based Gilmore Oral Reading Tests before and after 3 monthe of remedial work

Gilmore Test	Male			Female			All		
	Pre	Post	Gain	Pre	Post	Gain	Pre	Post	Gain
Accuracy	3.0	4.5	1.5	2.3	3.8	1.5	2.8	4.3	1.5
Comprehension	3.5	5.3	1.8	2.9	4.5	1.6	3.3	5.1	1.8

1.5 years and on Comprehension the gain was 1.8 years. Statistical analysis indicated the gains were significant. It is important to

TABLE 7

Comparison of Gilmore grade equivalents* divided by chronological age for 21 boys and 7 girls before and after 3 months of remedial work

Gilmore Test		Male	Female	All
	Pre	81.0	96.9	84.9
Accuracy	Post	99.8	105.4	101.2
	Gain	18.8	8.5	16.3
	Pre	88.6	103.0	92.2
Comprehension	Post	104.7	109.0	105.8
	Gain	16.1	6.0	13.6
	Pre	105.3	106.1	105.5
Full Scale I.Q.	Post	120.1	120.4	120.2
	Gain	14.8	14.3	14.7

65 months or the average chronological age for children entering first grade in Florida was added to the grade equivalent to obtain quotients comparable changes in I.Q.

point out here that this reading improvement was not accomplished by working with standardized and recognized reading procedures, but rather by using compensations and specialized techniques to improve ability to understand the words seen. In addition there was apparently an improvement in the child's self-concept. The gain for boys and girls is strikingly similar.

Another way to make a comparison is to convert the grade equivalent to an age equivalent by adding 65 months (average age of Florida children entering first grade) and then calculating a quotient by dividing the reading age equivalent by the chronological age. These calculations are shown in Table 7. It will be noted that at the beginning of the remedial work, these children were reading on a level which was well below that expected for their chronological ages, but their I.Q. averaged approximately 105.

In the post-testing, at the end of approximately three months, the children had risen in Accuracy to 101 per cent and in Comprehension to 105 per cent, or very slightly above their chronological age level, but their average I.Q. during the same period had on the average increased from 105-120. However, the actual amount of gain, 16 points for Accuracy, 14 for Comprehension and 15 for I.Q., are surprisingly similar. Only one child and only in Comprehension

TABLE 8

Comparison of age equivalents in years for 21 boys and 7 girls on the Frostig Test before and after 3 months of remedial work

Frostig Test		Male	Female	All
	Pre	7.6	7.5	7.6
Eye-Motor	Post	8.9	9.0	8.9
Coordination	Gain	1.3	1.5	1.3
	Pre	7.3	6.7	7.1
Figure Ground	Post	8.7	8.8	8.7
	Gain	1.4	2.1	1.6
	Pre	6.6	6.1	6.5
Form Constancy	Post	8.6	9.0	8.7
	Gain	2.0	2.9	2.2
	Pre	7.5	6.7	7.3
Position in Space	Post	8.4	8.7	8.5
	Gain	0.9	2.0	1.2
	Pre	7.7	7.1	7.5
Spatial Relations	Post	8.7	8.7	8.7
	Gain	1.0	1.6	1.2
	Pre	10.0	8.6	9.7
Age	Post	10.3	8.8	9.9
	Gain	0.3	0.2	0.2

scored lower at the post-testing period. It would be premature to try to explain here exactly what took place with these children, but there can be no question that the techniques used resulted in material improvement in I.Q. and in reading Accuracy and Comprehension.

Tables 8 and 9 show comparable data on the Frostig test for that data represented in Tables 6 and 7 on reading ability. Because the Frostig test does not extend past the age of 9 or 10 years, the children who were more than 10 years of age at the preremedial test were eliminated from the data in Table 9, but all children were considered in the data in Table 8.

Table 8 compares the age equivalents for all children, separates males from females, and combines both groups to show the average change at the end of the three months of remedial work. There appears to be the possibility that some sex difference exists. The

TABLE 9

Comparison of Frostig age equivalents divided by chronological age for 11 boys and 5 girls based on tests before and after 3 months of remedial work

Frostig Test		Male	Female	All
	Pre	75.5	87.4	79.2
Eye-Motor	Post	96.7	112.2	101.6
Coordination	Gain	21.2	24.8	22.4
	Pre	87.4	80.6	85.3
Figure Ground	Post	103.0	116.0	107.1
	Gain	15.6	35.4	21.8
	Pre	72.4	81.8	75.6
Form Constancy	Post	99.4	120.0	105.8
	Gain	27.0	38.2	30.2
	Pre	85.8	88.4	86.6
Position in Space	Post	96.3	114.0	101.8
	Gain	10.5	25.6	15.2
	Pre	91.4	92.4	91.4
Spatial Relations	Post	103.4	114.0	106.7
	Gain	12.0	21.6	15.0
	Pre	105.0	110.4	106.7
Full Scale I.Q.	Post	123.0	120.2	122.1
	Gain	18.0	9.8	15.4

responses of the two sex groups as shown in Table 8 are not always similar. It will be noted that the post-remedial scores are comparable. Nevertheless, improvement was striking. Among the younger children, scores above chronological age were often attained.

Table 9 considers the same data by dividing the Frostig age equivalent by the chronological age of those children that were less than 10 years of age at the time the testing started. The Full Scale I.Q. is shown at the bottom of the table to show comparative change. The girls show a much greater gain than do the boys, and the gain for the girls is out of proportion to the gain in I.Q. In fact, the gain in the Frostig was greater than for Full Scale I.Q. The gain on individual Frostig sub-test scores for the boys was erratic and was both below and above the gain on Full Scale I.Q. Girls, however, showed greater improvement on all Frostig sub-tests. The

largest gain was registered for both boys and girls on Form Constancy on which they had been the lowest at the beginning of remediation. Because of the small number of children, no significance should be drawn from these data for an individual sub-test, but it is significant that with the techniques used, the visual perceptual gain so far as measured by the Frostig test was considerable, and was in excess of that found with I.Q. as measured by the WISC, or reading ability as measured by the Gilmore.

It is, perhaps, of importance to note that on the WISC scale scores, the sub-test for Object Assembly showed a greater average increase for all children than for any other sub-test. Similarly, for the Frostig test, the greatest gain was on Form Constancy, a subtest that in many respects is comparable to the WISC Object Assembly. It would appear that something had taken place to materially improve this aspect of a child's visual perceptual ability.

Some of the children in this series were seen for a period of time following the initial three months of remediation, and certain observations concerning them are in order. One boy who was 11 years old at the time testing began had an initial I.Q. of 79, and increased only to 88 with mild improvement in reading ability. Three months were simply not enough in the case of this child, because in the months that followed, the improvement increased at a very rapid rate. It was as though a sudden break-through had occurred in the child's comprehension. In some other instances when remedial work was discontinued the child appeared to suffer some relapse over the course of the next few months. This appears at this time to occur most often in older children. Some children will probably require continuing or periodic remediation work, whereas others may not. Certainly the age of the child before beginning remedial work, the intensity of his visual perceptual difficulties, and the state of his self-concept appear to be major factors in the rapidity of response to treatment and the final successful termination of that response. It is obvious from this study that it varies markedly from child to child. It is anticipated that with sufficient knowledge, some prognosis on the child might well be possible, but in the present status of understanding about this complex of problems, there seems little chance to be sure exactly what should be done and how long it will take. However, the present study clearly indicates that all of the children in this study responded in terms of their visual

perceptive abilities as measured by the Frostig test, in their Accuracy and Comprehension in reading and in their general Intelligence Quotient. This was true regardless of the status of the child at the beginning of remedial work. It was true without exception as these children represent all those who began and continued remedial activities for as long as ten weeks under the author's direction. No failures were encountered, and the result would be strongly indicative that none of these children were suffering from brain damage, but were strictly the victims of visual perceptual difficulties.

Summary and Conclusions

Of 32 children who entered a private clinic because of reading difficulties usually associated with behavioral problems, 21 boys and seven girls undertook and completed a three month period of remedial treatment. These children tended to have a high variability among sub-tests on the WISC, a high Comprehension scale score as compared with both information and Arithmetic, and a higher Verbal than Performance I.Q. Age equivalent scores were well below chronological age on most individual Frostig sub-tests. Reading levels as judged by the Gilmore Oral Reading Test were well below suggested I.Q. capabilities. Seventy-five per cent of the children demonstrated mixed laterality and approximately 85 per cent were or had been hyperactive.

Statistical analysis indicated significant improvement in reading ability, visual perception, and I.Q. Improvement in arithmetic was not obtained.

The study is suggestive that children with visual perceptual problems accompanied by reading difficulties can be helped with one-to-one sessions which include individualized techniques related to each childs specific problem areas. Improvement in self concept is important to improvement in reading ability and behavior pattern.

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New Host Records of *Capillaria hepatica* in Florida

James N. Layne

The parasitic nematode *Capillaria hepatica* (Bancroft, 1893), a member of the family Trichiuridae, typically occurs in the adult stage in the liver of mammals. It has previously been recorded in Florida from the cotton rat, *Sigmodon hispidus*; cotton mouse, *Peromyscus gossypinus*; and Florida mouse, *Peromyscus floridanus* (Layne and Griffo, 1961; Layne, 1968). This paper reports the occurrence of this parasite in two additional Florida mammals, the cottontail rabbit (*Sylvilagus floridanus*) and roof rat (*Rattus rattus*) and gives information on its incidence in different hosts and habitats on the Archbold Biological Station in southern Florida.

Capillaria hepatica has previously been recorded from *Sylvilagus floridanus* in Oklahoma by Ward (1934), but there appears to be no well substantiated earlier record of *Rattus rattus* as a host in the United States. Hall (1916) listed *Rattus rattus* as one of the hosts of *C. hepatica* but did not distinguish between this species and *Rattus norvegicus* in the U.S. records cited.

One (5.8 per cent) of 17 *Sylvilagus floridanus* examined from various localities and habitats in Polk and Highlands Counties was infected with *C. hepatica*. This specimen was collected on 14 July 1969 in scrubby flatwoods habitat 12 miles S of Lake Placid, Highlands Co. Only a few scattered lesions were visible in the liver. No *C. hepatica* infections were recorded in 12 cottontails examined from four habitat types in an earlier study (Layne, 1968), and it appears that this is not a common parasite of rabbits in this state. Ward (1934) did not give data on prevalence of *C. hepatica* in cottontails in Oklahoma.

All infections in *Rattus rattus* were recorded from the Archbold Biological Station located in Highlands Co., 8 miles S of Lake Placid. Approximately 600 specimens of 16 species of mammals collected on the 1050-acre area of the Station have been examined for *C. hepatica* infections. The general habitat types that have been sampled are described below.

Main grounds. A park-like area of lawns, clumps of shrubbery, scattered trees, and buildings and also including a nearby poultry yard and small vegetable garden.

Cultivated. An area of approximately 11 acres containing citrus

and other fruit trees; ornamental trees and shrubs; vegetable gardens; pineapple patches; weedy, fallow areas; and brushpiles.

Slash pine-turkey oak woodland. A relatively xeric habitat with large, rather widely spaced southern slash pine (*Pinus elliottii densa*) and a shrubby understory of turkey oaks (*Quercus laevis*) and other species. Grasses, chiefly wire grass (*Aristida*), and forbs are comparatively common. The soil is sandy and well drained.

Sand pine scrub. Mature stands of sand pine (*P. clausa*) ranging from a nearly closed to widely open canopy with a dense shrub layer of various oaks and other species and sparse herbaceous ground cover. The litter layer is generally well developed; the soil is sandy and well drained.

Scrubby flatwoods. Scattered southern slash pines with a dense shrub layer of many of the same species found in the previous association. The soils of sand pine scrub and scrubby flatwoods are generally similar as well.

Low flatwoods. This habitat is moister than the three preceding ones as a result of denser vegetation and more poorly drained soil. The dominant tree is southern slash pine, which often occurs in fairly dense stands with a thick understory of shrubs and palmetto. In other cases the shrubs and palmettos are few and widely dispersed, and there is a dense ground cover of grasses.

Bayhead. A low area of southern slash pine, loblolly bay (*Gordonia lasianthus*), sweetbay (*Magnolia virginiana*), and red bay (*Persea borbonia*) with an abundance of shrubs, ferns, forbs, and vines. The soil is rich in organic matter and poorly drained. This is the moistest environment of the series.

Nine (8.2 per cent) of 109 *Rattus* examined had grossly visible *C. hepatica* infections. Incidence of infections in different habitat types are given in Table 1. Infections of eight specimens were rated as to severity on the basis of criteria described by Layne (1968). Seven individuals had light infections and one a moderate infection. This suggests that *Rattus rattus* does not ordinarily become heavily infected with *Capillaria hepatica*, which agrees with findings for *R. norvegicus* (Herman, 1939; Luttermoser, 1936).

Comparative data on *Capillaria* infections in other species of mammals collected from the Archbold Station are also given in Table 1. Overall prevalence in each of these species is as follows: cotton rat (*Sigmodon hispidus*), 3.7 per cent; cotton mouse (*Peromyscus gossypinus*), 2.8 per cent; Florida mouse (*Peromyscus flori-

TABLE 1

Incidence of *Capillaria hepatica* infections in four species of rodents in various habitats on the Archbold Biological Station, Highlands County, Florida.

	Rattus rattus			*Sigmodon hispidus*			*Peromyscus gossypinus*			*Peromyscus floridanus*		
Habitat	No. exam.	No. inf.	o/o inf.	No. exam.	No. inf.	o/o inf.	No. exam.	No. inf.	o/o inf.	No. exam.	No. inf.	o/o inf.
Main grounds	60	2	3.3	38	0	0	12	0	0			
Cultivated	26	1	3.8	24	2	8.3	2	0	0			
Slash pine-turkey oak	2	1	50.0	7	0	0	23	1	4.3	38	23	60.5
Sand pine scrub	5	3	60.0	2	0	0	29	2	6.9	22	15	68.2
Scrubby flatwoods	3	0	0				4	0	0	45	28	62.2
Low flatwoods				13	1	7.7	37	0	0			
Bayhead				1	0	0						
Unknown	13	2	15.4	22	1	4.5						

danus), 62.8 per cent. Two of three *Sigmodon* in which degree of infection was noted had light infections, and the third animal had a moderate infection. All infections recorded in *P. gossypinus* were classified as light. In contrast, of a total of 64 infections rated as to severity in *P. floridanus*, 12 were light; 34 moderate; and 18, heavy.

The occurrence of *Capillaria hepatica* in small mammals on the Archbold Station shows a strong association with relatively xeric scrub-like vegetation types (Table 1). This correlation has been previously noted in Florida by Layne and Griffo (1961) and Layne (1968). *P. floridanus*, which is closely confined to the slash pine-turkey oak, sand pine scrub, and scrubby flatwoods habitats, exhibits both the highest incidence and greatest intensity of infections. In contrast, the lower prevalence and severity of infections in the other three host species is associated with their broader ecological distribution on the Station. The restriction of the parasite to drier vegetative types on the Station may be even greater than the data indicate. Live trapping studies have shown that both *Rattus* and *P. gossypinus* are more mobile than *P. floridanus* and often move considerable distances from one habitat type to another. Thus, some of the infections found in these species in the non-typical habitats might actually have been acquired in the slash pine-turkey oak, scrub, or scrubby flatwoods associations. It is further possible that *C. hepatica* is not self maintaining in the less xeric habitats of the Station and that its occurrence and prevalence in these environments depends entirely upon movements of animals from the drier habitats.

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Deep-water Algae New to Puerto Rico

Luis R. Almodóvar

Several reports concerning the taxonomy and ecology of benthic marine algae of Puerto Rico have been published during recent years (Almodóvar and Blonquist, 1959, 1961, 1965; Almodóvar, 1962, 1964a, 1964b; Díaz, 1963; Taylor, 1960).

A study of the ecology of the deep-water algae off La Parguera, Puerto Rico started in 1966 as a project sponsored by the Office of Naval Research, United States of America, under contract no. N-00014-66-C-0330. During the following three years algal specimens were collected by dredging, SCUBA, and by growth in artificial substrata. Twenty-one species were found new to Puerto Rico. It seems appropriate to publish these records, since such information forms an addition to the knowledge of the distribution of marine algae in the West Indies.

Catalogue of Species

Abbreviations used to designate the location conform to those proposed in the Index Herbariorum, part 1 Ed. 5 (1964). Exceptions (not found in the Index) are indicated by an asterisk. They are as follows: ADU, University Adelaide, Australia; *D, Herbarium of Francis Drouet; DUKE, Herbarium, Duke University; *IMB, Herbarium, Department Marine Sciences, University of Puerto Rico; L, Rijksherbarium, Leiden; NY, New York Botanical Garden; UC, University of California; US, United States National Museum.

Chlorophyta: Valoniaceae

Dictyosphaeria vanbosseae Børgesen. Guánica: SCUBA, 60′ in *Strombus gigas*, aboard R/V *Medusa, L. R. Almodóvar, F. Pagan, V. M. Rosado, J. Rees, H. Austin,* and *Captain Frederick 5464,* 17 February 1967 (IMB, NY).

Dasycladaceae

Neomeris mucosa M. A. Howe. Guánica: SCUBA, 60′, on *Strombus gigas, L. R. Almodovar, F. Pagan, V. M. Rosado, J. Rees, H. Austin,* and *Captain Frederick 5496,* 17 February 1967 (IMB).

Codiaceae

Udotea spinulosa M. A. Howe. Cabo Rojo: Dredged, 60′-100′, aboard MR/V *Carite,* off Margarita Reef, in sandy bottom, *L. R. Almodovar, V. M. Rosado, F. Pagan, J. J. Irizarry* and *Captain Felix 6501,* 10 April 1967 (IMB, NY, US).

Udotea wilsoni Gepp and Howe. La Parguera: SCUBA, in 55′, sandy bottom, off Laurel Reef, *L. R. Almodovar, F. Pagan, H. Austin, Jose Gonzalez, J. J. Irizarry* and *V. M. Rosado 5669,* 12 June 1967 (IMB).

Phaeophyta: Dictyotaceae

Dictyopteris jamaicensis Taylor. La Parguera: in 80′, off Margarita Reef, *V. M. Rosado* and *J. J. Irizarry 5997,* 4 August 1969 (IMB).

Dictyopteris membranacea (Stackhouse) Batters. Guánica: Dredged, aboard MR/V Carite, 3 miles off Punta Brea, *L. R. Almodovar, F. Pagan, V. M. Rosado* and *Captain Felix 5385,* 28 November 1966 (IMB, L, NY, US).

Rhodophyta: Dumontiaceae

Dudresnaya crassa M. A. Howe. Guanica: Dredged, aboard MR/V Carite, in 50′-60′, 3 miles off Punta Brea, *L. R. Almodovar, F. Pagan, V. M. Rosado* and *Captain Felix 5417,* 12 December 1966 (IMB, NY, US). La Parguera: Dredged, aboard MRV/Carite, 45′-60′, 4 miles off Media Luna Reef, *L. R. Almodovar, F. Pagan, V. M. Rosado, W. Irizarry* and *Captain Felix 5547,* 28 February 1967 (IMB); SCUBA, sandy-rocky bottom, 55′, off Laurel Reef, *L. R. Almodovar, F. Pagan, H. Austin, Jose G. Liboy, J. J. Irizarry* and *V. M. Rosado 5666,* 12 June 1967 (IMB).

Grateloupiaceae

Corynomorpha clavata (Harvey) J. Agardh. La Parguera: Dredged, aboard MR/V *Carite,* 50′, in sandy bottom, off Media Luna Reef, *L. R. Almodovar, V. M. Rosado, F. Pagan, J. J. Irizarry,* and *Captain Felix 5660,* 1 May 1967 (IMB).

Halymenia agardii De Toni. Guanica: Dredged, in 50′-60′, aboard R/V *Medusa,* off Punta Brea, *L. R. Almodovar, F. Pagan, V. M. Rosado, H. and S. Austin, J. Rees,* and *Captain Frederick 5454A,*

17 January 1967 (IMB). La Parguera: Dredged, 50′-60′, aboard MR/V *Carite,* in sand off Media Luna, *L. R. Almodovar, V. M. Rosado, Jose A. Gonzalez,* and *Captain Felix 5710,* 20 June 1967 (IMB); dredged, aboard MR/V *Carite,* in sand, 50′-70′, off Media Luna Reef, *L. R. Almodovar, V. M. Rosado, J. J. Irizarry, W. Irizarry* and *Captain Felix 5810,* 1 March 1968 (IMB).

SOLIERIACEAE

Eucheuma schrammi (Crouan) J. Agarth. Guanica: Dredged, aboard MR/V *Carite,* 3 miles off Punta Brea, 70′-100′, *L. R. Almodovar, F. Pagan, V. M. Rosado,* and *Captain Felix 5369,* 28 November 1968 (IMB, NY). La Parguera: Dredged, aboard MR/V *Carite,* sandy bottom, 50′-70′, *L. R. Almodovar, V. M. Rosado, J. J. Irizarry* and *Captain Felix 5821,* 1 March 1968 (IMB, NY).

KALLYMENIACEAE

Kallymenia limminghii Montagne. Guanica: Dredged, 3 miles in 50′-60′, aboard MR/V *Carite,* off Punta Brea, *L. R. Almodovar, V. M. Rosado, H. and S. Austin, J. Rees,* and *Captain Frederick 5448,* 17 January 1967 (IMB, NY, US).

RHODYMENIACEAE

Botryocladia pyriformis (Børgen) Kylin. Guanica: Dredged, 3 miles off Punta Brea, 70′-100′, *L. R. Almodovar, V. M. Rosado, F. Pagan, Captain Felix 5381,* 28 November 1966, (IMB); SCUBA, aboard R/V *Medusa,* in 60′, on *Strombus gigas, L. R. Almodovar, F. Pagan, V. M. Rosado, J. Rees, H. Austin* and *Captain Frederick 5487,* 17 February 1967 (IMB). La Parguera: Dredged, in 45′-60′, 4 miles off Media Luna Reef, sandy bottom, *L. R. Almodovar, F. Pagan, V. M. Rosado, Captain Felix,* and *W. Irizarry 5511,* 28 February, 1967. (IMB, NY); Dredged, aboard MR/V *Carite,* in sandy bottom, 50′, off Media Luna Reef, *L. R. Almodovar, V. M. Rosado, F. Pagan, J. J. Irizarry* and *Captain Felix 5657,* 1 May 1967 (IMB); SCUBA, off Punta Jorobado, in 45′ *L. R. Almodovar, H. and S. Austin, F. Pagan, F. Suau, J. Gonzalez, V. M. Rosado* and *J. J. Irizarry 5680,* 16 June 1967 (IMB); dredged, aboard MR/V *Carite,* on flat bottom, 50′-70′, off Media Luna Reef, *L. R. Almodovar, V. M.*

Rosado, J. J. Irizarry, W. Irizarry and *Captain Felix 5765,* 1 March 1968 (IMB).

Chrysymenia halymenioides Harvey Guánica: Dredged, aboard MR/V *Carite,* 3 miles off Punta Brea, in 70′-100′, L. R. Almodovar, *F. Pagan, V. M. Rosado* and *Captain Felix 5386,* 28 November 1966 (IMB, L, NY). La Parguera: Dredged, aboard MR/V *Carite,* off Media Luna Reef, 50′-70′, *L. R. Almodovar, V. M. Rosado, J. J. Irizarry* and *Captain Felix 5811,* 1 March 1968 (IMB, NY).

Coelarthrum albertisii (Picone) Børgesen. Guánica: Dredged, aboard MR/V *Carite,* 3 miles off Punta Brea, in 70′-100′, *L. R. Almodovar, F. Pagan, V. M. Rosado* and *Captain Felix 5379,* 28 November 1966 (IMB).

CERAMIACEAE

Callithamnion cordatum Børgesen. La Parguera: Dredged, aboard, MR/V *Carite,* 45′-60′, 4 miles off Media Luna Reef, *L. R. Almodovar, F. Pagan, V. M. Rosado, W. Irizarry* and *Captain Felix 5508,* 28 February 1967 (IMB).

Ceramiun corniculatum Montagne. La Parguera: Dredged, aboard MR/V *Carite,* in 45′-60′, 4 miles off Media Luna Reef, *L. R. Almodovar, F. Pagan, V. M. Rosado, W. Irizarry* and *Captain Felix 5532,* 28 February 1967 (IMB).

Crouania pleonospora. La Parguera: On *Bucera buceras,* artificial substratum, 60′, *L. R. Almodovar* and *V. M. Rosado 5902,* 8 May 1968 (IMB).

Griffithsia schousboei Montagne. La Parguera: Dredged, aboard MR/V *Carite,* in sandy bottom, 50′-70′, off Media Luna Reef, *L. R. Almodovar, V. M. Rosado, J. J. Irizarry* and *Captain Felix 5801,* 1 March 1968 (IMB); dredged, in 40′-50′, sandy bottom, off Margarita Reef, *L. R. Almodovar, V. M. Rosado* and *J. J. Irizarry 5846,* 27 March 1968 (IMB); SCUBA, off Media Luna Reef, *L. R. Almodovar, H. and S. Austin, J. Gonzalez, V. M. Rosado* and *J. J. Irizarry 5852,* 17 April 1968 (IMB).

DASYACEAE

Dasya caraibica Børgesen. La Parguera: Dredged, aboard MR/V *Carite,* on sandy bottom, 50′-60′, off Media Luna Reef, *L. R. Almodovar, V. M. Rosado, Jose A. Gonzalez, W. Irizarry* and *Captain Felix 5715,* 20 June 1957 (ADE, D, DUKE, IMB, NY, UC);

dredged, aboard MRV/CARITE, 50′-70′, off Media Luna Reef, *L. R. Almodovar, V. M. Rosado, J. J. Irizarry, W. Irizarry* and *Captain Felix 5803,* 1 March 1968 (IMB, NY).

Dasya crouaniana J. Agardla. La Parguera: Dredged, aboard MR/V *Carite,* off Media Luna Reef, on sandy bottom, 50′-70′, *L. R. Almodovar, V. M. Rosado, J. J. Irizarry, W. Irizarry* and *Captain Felix 5776,* 1 March 1968 (IMB, NY).

RHODOMELACEA

Laurencia lata Howe and Taylor. La Parguera: Dredged, 45′-60′, sandy bottom, 4 miles off Media Luna Reef, *L. R. Almodovar, F. Pagan, V. M. Rosado, W. Irizarry* and *Captain Felix 5546,* 28 February 1967 (IMB).

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The Immature Stages of Some Chironomini (Chironomidae)

William M. Beck, Jr. and Elisabeth C. Beck

Descriptions of the larvae and pupae of the nine species included in this paper are based on cast skins of specimens reared during the course of a study of the Florida Chironomidae. All except *Paralauterborniella nigrohalteralis* are previously undescribed, although Darby (1962) does give figures for some parts of the larva and pupa of *P. elachista*. Since *P. nigrohalteralis* was described by Lenz (1962) in European literature, we felt it would be worthwhile to include a redescription here. One new species, *Einfeldia austini*, is described as adult, larva, and pupa.

Omisus pica Townes

Larva (Fig. 1*a-d*). Head capsule pale yellow, labial and mandibular teeth dark brown. Labial plate with 14 teeth, median pair shorter than first laterals and roughly triangular; first and second laterals close together and longer than other teeth; paralabials striate to anterior margin; mandible with pale dorsal, dark apical and three dark lateral teeth, accessory tooth pale, slender, curved, reaching almost to apex of second lateral tooth. Antennal ratio 100:18:23:18:8.5, lauterborn organs at apex of second and third segments, blade to middle of fourth; inner margin of mandible with two to four fine spines, apical comb and basal brush present; claws of posterior prolegs yellow, curved; anal papillae with seven or eight pale bristles.

Pupa (Fig. 2*e-f*). Brown, 6.5 mm long; cephalic tubercle very small, acutely pointed, with short subapical bristle. Tergite I bare, II with anterior and posterior shagreen and a posterior row of about 20 dark hooks; III-V with fine shagreen and a pair of patches of dark brown spines set in a brown area just anterior to middle of the segment. In addition IV has on each caudo-lateral area a patch of anteriorly directed coarse brown spines; VI with faint shagreen on anterior half; VII and VIII bare. Caudo-lateral spur of VIII composed of about eight paler spines; lateral filaments of V-VIII: 3-3-4-5-; anal fins widely brown on lateral margins with 30-32 filaments on each lobe.

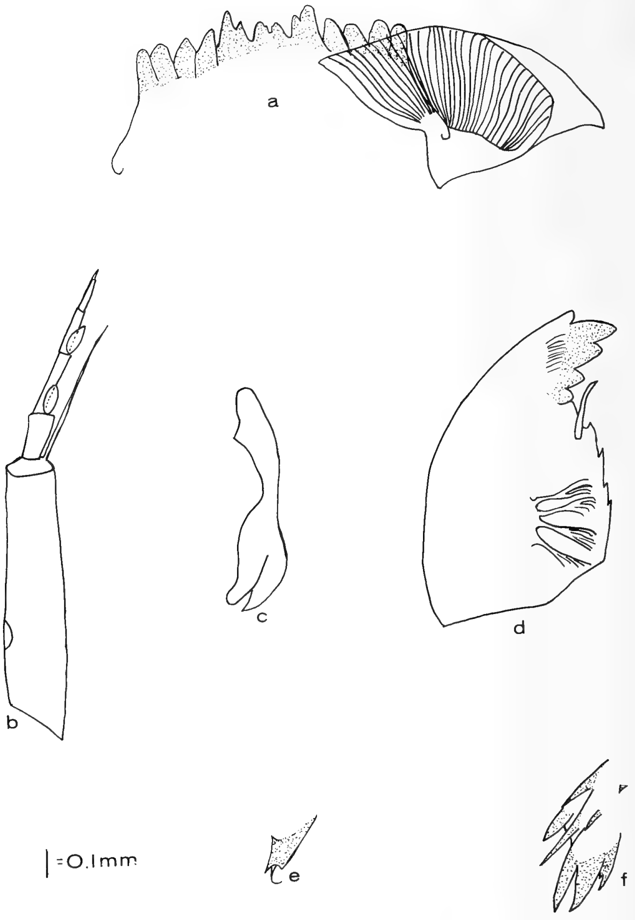

Fig. 1. *Omisus pica*, details of larva (*a-d*) and pupa (*e-f*). *a* labial plate and paralabial, *b* antenna, *c* premandible, *d* mandible, *e* cephalic tubercle, *f* lateral spur on segment VIII.

Paralauterborniella elachista (Townes)

Larva (Fig. 2*a-d*). Head capsule very pale yellow, labial plate with two long pale median teeth and five dark laterals, the first notched on inner margin; paralabials fairly short, pointed at median ends; premandible pale yellow with three broad blades and a lateral projection; mandible with pale dorsal tooth, a dark apical and three dark laterals, accessory tooth long, curved, pointed at apex, both brush and mandibular comb present. Antennal ratio 50:12:14:10:7:4, blade to apex of third segment. Anal papillae with seven long bristles.

Pupa (Fig. 2*e*). Very pale, with cephalothorax slightly brownish, 2.7 mm long. No cephalic tubercles, but a long bristle. Tergite II has posterior row of 28 hooks and a band of shagreen anterior to this. Tergites III-VI with a median area of shagreen with heavier spines on anterior and posterior parts; intersegmental spines on IV-V; tergite IV with whorls of spines near caudo-lateral border. Segment VIII has caudo-lateral spur of two smaller and one large brown spines. Lateral filaments on V-VIII: 4-4-4-5; anal fins with 22—24 lateral filaments plus one smaller, about half way from base on outer margin.

Paralauterborniella nigrohalteralis (Malloch)

Larva (Fig. 2*f-i*). Head capsule light brown, occipital rim darker; labial plate with median domed clear tooth and six pointed dark laterals on each side; paralabials long and pointed at ends; pre-mandible yellow with two slender blades; mandible with apical tooth golden yellow and four small lateral teeth slightly darker yellow; antennal ratio 50:16:12:4:6:6, blade to apex of fourth segment; claws of posterior prolegs simple, yellow; anal papillae with long yellow bristles.

Pupa (Fig. 2*j-k*). Dark grey-brown, 2.7 mm long; cephalic tubercles large, pointed, with long subapical bristle. Segment I has anterior lateral lobes; segment II has posterior lateral lobes. Tergite II has about 18 almost colorless hooks in posterior row; tergites II-V with broad median longitudinal band of shagreen; intersegmental spines on III-IV and IV-V. Tergites VII and VIII without shagreen, VIII with a caudo-lateral spur of three or four dark

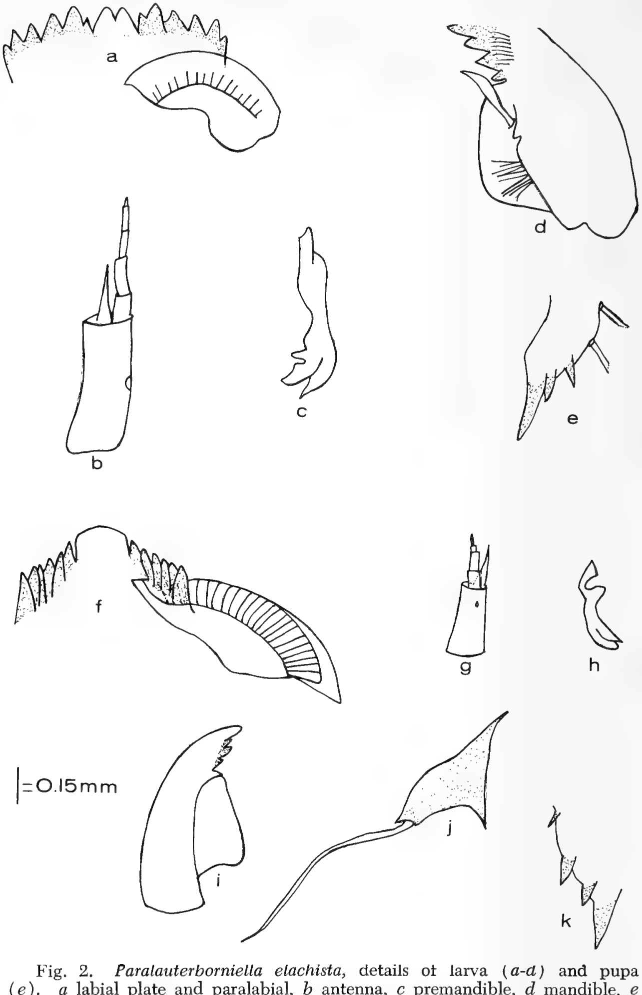

Fig. 2. *Paralauterborniella elachista*, details of larva (*a-d*) and pupa (*e*). *a* labial plate and paralabial, *b* antenna, *c* premandible, *d* mandible, *e* lateral spur on segment VIII. *Paralauterborniella nigrohalteralis*, details of larva (*f-i*) and pupa (*j-k*). *f* labial plate and paralabial, *g* antenna, *h* premandible, *i* mandible, *j* cephalic tubercle, *k* lateral spur of segment VIII.

spines; lateral filaments on V-VIII: 4-4-4-4; anal fins with 20-25 lateral filaments, plus one on the disc about four-fifths from base of segment.

Stenochironomus hilaris (Walker)

Larva (Fig. 3*a-c*). Head capsule golden brownish, labial teeth and apical half of mandible black. Labial plate with ten teeth, the outer three projecting on each side. Antennal ratio 50:13:6:6:?; claws of anterior prolegs strongly curved, mostly short.

The larvae of known *Stenochironomus* species are buprestid-like, having a broad flat thorax and a very slender long abdomen; prolegs are retractile except for the claws. The paralabials, unlike those of all other known genera of Chironominae, are not striated.

Pupa (Fig. 3*d*). Light brown, about 8.7 mm long; cephalic tubercles low, rounded, lobe-like, no bristle; tergite I bare, II-V with anterior band of heavy spines and most of segment covered in fenestrated shagreen, apical band of spines separated from shagreen on V; VI with T-shaped patch of fine shagreen and a broad apical band of heavier spines; VII and VIII bare; VIII with caudo-lateral spur of four broad blunt golden spines. Tergite II has apical band of golden hooks almost as wide as the segment; intersegmental spines on IV-V; lateral filaments on V-VIII: 4-4-4-5; anal fin with 85-90 lateral filaments.

Stenochironomus aestivalis Townes

Larva (Fig. 4*a-c*). Head yellow-brown, labial teeth and apical one-third or more of mandible black. Antennal ratio 50:18:5:8:2, blade to apex of second segment; claws of anterior prolegs golden, small, strongly curved and dense; claws of posterior prolegs blackish.

Pupa (Fig. 4*d*). Light brown, approximately 5 mm long; cephalic tubercles are wrinkled rounded lobes, no bristle. Tergite I with faint median shagreen; II has apical row of small hooks, the row only about one-third as wide as the segment; tergites II-VI with broad median longitudinal band of shagreen, the spines finest in the middle of each segment; VII has similar median band of shagreen, much finer; VIII has antero-lateral patches of fine shagreen, and a small median patch; lateral filaments on V-VIII: 4-4-4-5; caudo-lateral spur on VIII has one or two very large, heavy, short

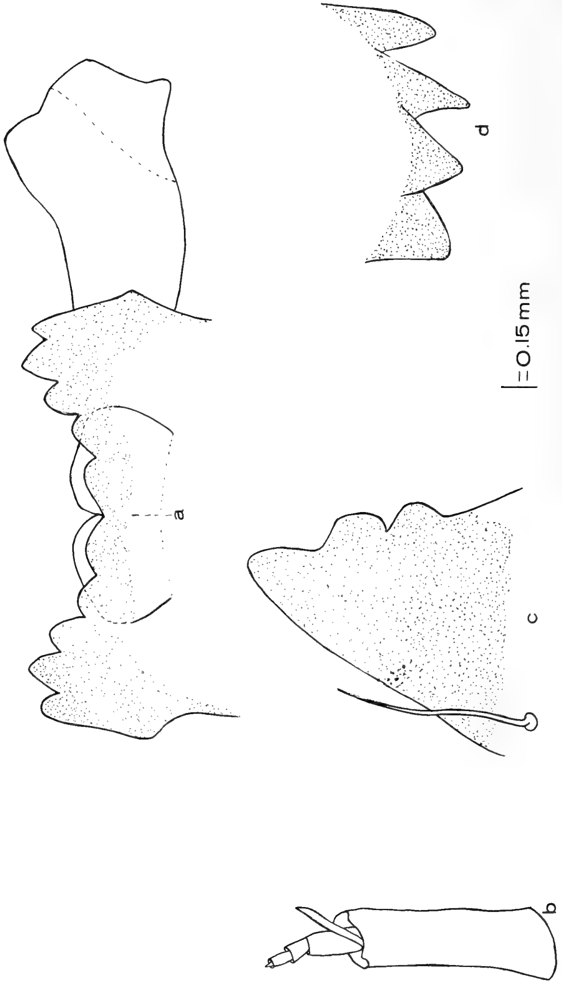

Fig. 3. *Stenochironomus hilaris,* details of larva (*a-c*) and pupa (*d*). *a* labial plate and paralabial, *b* antenna, *c* mandible, *d* lateral spur of segment VIII.

pale spines and may have two to four much smaller spines; about 56 lateral filaments on anal fin, plus a small one on disc near outer margin one-half way from base.

Stenochironomus cinctus Townes

Larva (Fig. 4*e-g*). Head yellow-brown, labial teeth and about apical third of mandible black. The larvae of *cinctus* and *aestivalis* are very similar. The characters which appear to separate them are: shape of paralabial plate, shape of hypopharangeal plates, and length of outer bristle of mandible. Since we have so few reared specimens (only one female of *cinctus*) it is impossible to be certain these characters will be consistent for a species.

Pupa (Fig. 4*h*). Pale brown, cephalothorax darker, about 6 mm long; cephalic tubercles low, wrinkled. Tergite I has faint shagreen medially; II has dense fine shagreen and a posterior row of hooks which is less than one-half the width of the segment; tergites III-VI with broad median longitudinal band of shagreen, finer at middle of the band; some of the anterior spines on IV are multiple, double to quadruple; tergite VII much as III-VI, but with finer shagreen; VIII has antero-lateral patches of fine shagreen and a caudo-lateral spur of one large and one small coarse pale spines; segments V-VIII bear 4-4-4-5 lateral filaments; about 52 lateral filaments on each lobe of the anal fins.

Nilodorum devineyae (Beck) new combination

Larva (Fig. 5*a-d*). Head capsule light brown, gular area darker. Labial plate with trilobed median and six laterals, the second lateral close to first; paralabials almost meeting at midline and finely striated to anterior edge; mandible with light dorsal tooth, dark apical and three dark laterals, comb and brush present on mandible, accessory tooth long and stout, reaching to third lateral tooth; antennal ratio 50:15:12:10:2, blade to middle of fourth segment; premandibles with two blades, the outer thin; claws of posterior prolegs yellow; anal papillae with seven bristles. No anal gills.

Pupa (Fig. 5*e-f*). Dark brown, 6.4 mm long; cephalic tubercles very small, acute, with short bristle; tergite I without shagreen, somewhat wrinkled in appearance laterally, with a pair of small clear spots caudo-medially; tergites II-VI almost covered with sha-

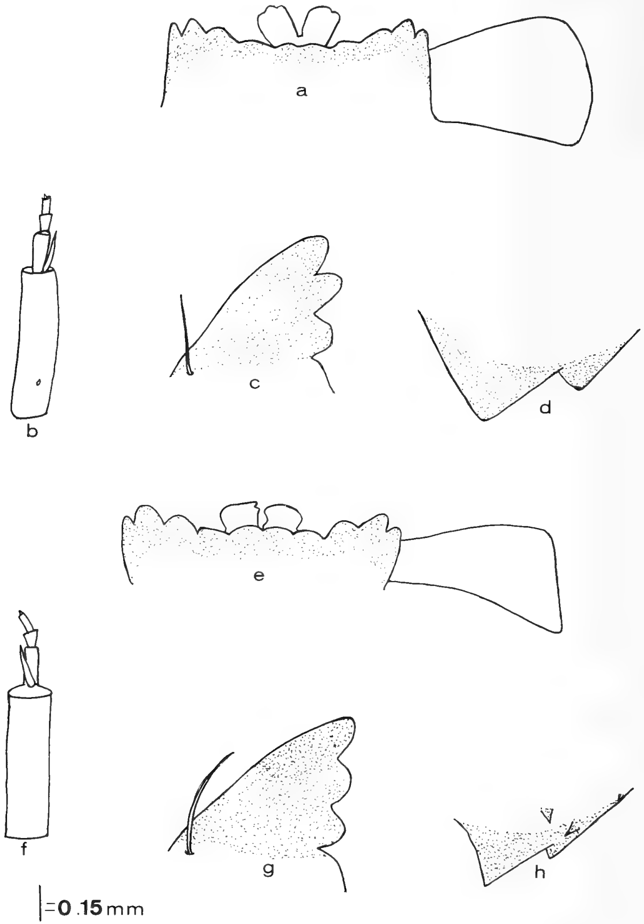

Fig. 4. *Stenochironomus aestivalis,* details of larva (*a-c*) and pupa (*d*). *a* labial plate and paralabial, *b* antenna, *c* mandible, *d* lateral spur on segment VIII. *Stenochironomus cinctus*, details of larva (*e-g*) and pupa (*h*). *e* labial plate and paralabial, *f* antenna, *g* mandible, *h* lateral spur on segment VIII.

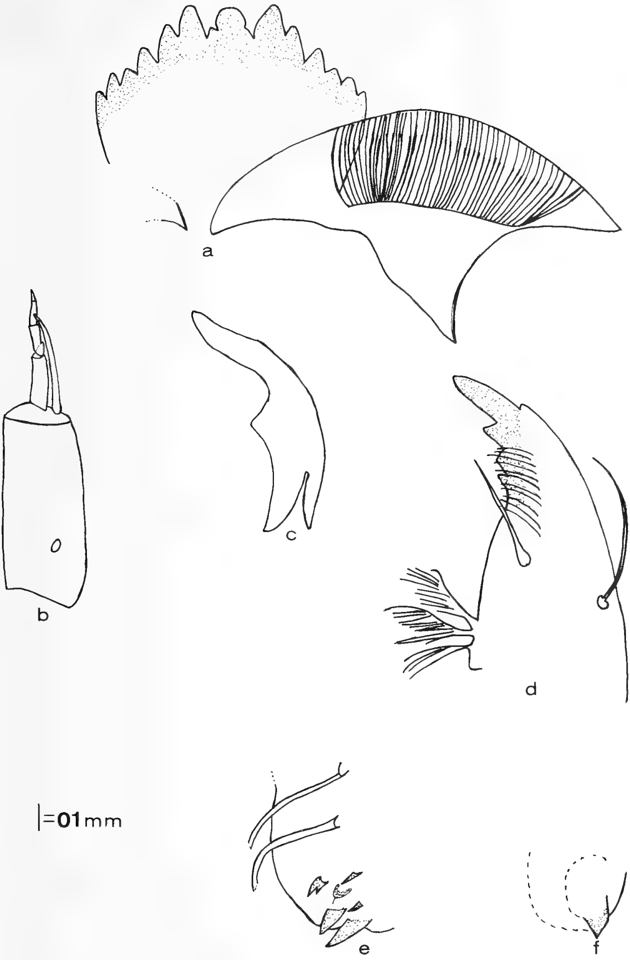

Fig. 5. *Nilodorum devineyae,* details of larva (*a-d*) and pupa (*e-f*). *a* labial plate and paralabial, *b* antenna, *c* premandible, *d* mandible, *e* lateral spur of segment VIII, *f* cephalic tubercle.

green which has heavier spines near base and caudal margins, and a clear median area near caudal margin; II has posterior row of dark hooks, more than one-half as wide as the segment; IV has caudo-lateral whorls of fine spines; VII and VIII have antero-lateral patches of fine shagreen; spur on VIII with two to five small dark spines; lateral filaments on V-VIII: 4-4-4-5; anal fins with fine shagreen on anterior one-fourth, about 40 lateral filaments on each lobe and one on disc about three-tenths from base of fin.

Kiefferulus dux (Johannsen) new combination

Larva (Fig. 6*a-d*). Head capsule light brown, labial teeth and teeth of mandible very dark brown; labial plate with trilobed median and six laterals, the second lateral smaller than the first and not completely separated from it; paralabials with fine striae to anterior margin; mandible with pale dorsal tooth, dark apical and three dark pointed laterals, shoulder squared, not darkened, accessory tooth pale, broad and serrate at apex; antennal ratio 100:34: 24:20:5, blade to apex of fourth segment; premandible broad with six darkened blades; claw of posterior prolegs yellow, curved; anal papillae with seven yellow bristles.

Pupa (Fig. 6*e-f*). Brown, 6.3 mm long; cephalic tubercles acutely pointed at apex with short subapical bristle; tergite I bare, II with posterior row of about 35 stout hooks; II-V with dense shagreen, spines heavier and suggesting paired patches apically on tergites IV and V; VI with subbasal band of fine spines and posterior median patch of heavier spines; intersegmental spines III-IV, IV-V, V-VI and VI-VII; lateral whorls of fine spines on IV; VII and VIII bare; spur on VIII composed of seven or more small spines; lateral filaments V-VIII: 4-4-4-5; about 90 lateral filaments on each lobe of anal fins.

This larva differs from that described by Johannsen (1937) in that he says "basal antennal segment two times as long as rest together." Johannsen's description of the pupa differs in having "Hook row II interrupted for a short distance in middle". Johannsen says that the larva of *insolita* Kieffer differs (from *dux*) ". . . . and in that it has a pair of gills on segment 11 . . . .". The larva of *K. dux* does have a pair of gills on segment 11 also.

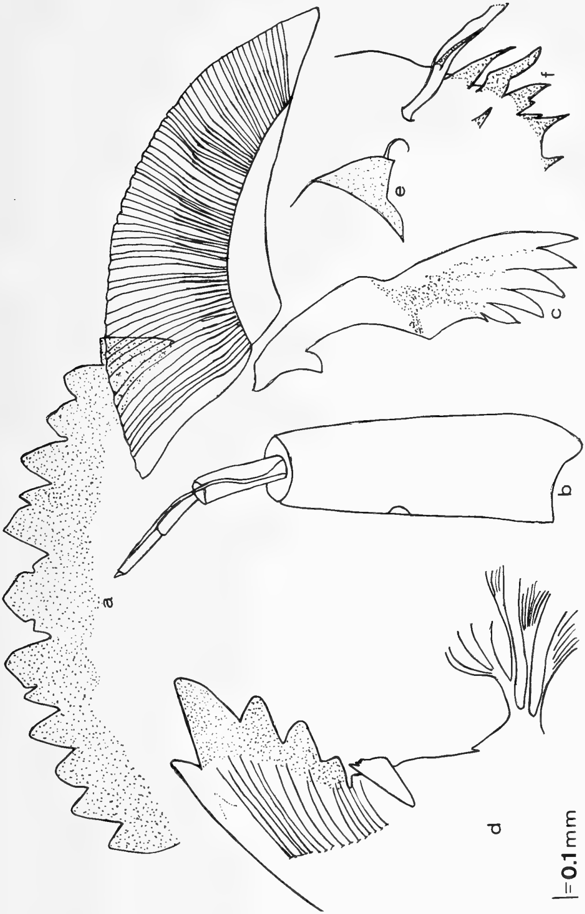

Fig. 6. *Kiefferulus dux,* details of larva (*a-d*) and pupa (*e-f*). *a* labial plate and paralabial, *b* antenna, *c* premandible, *d* mandible, *e* cephalic tubercle, *f* lateral spur of segment VIII.

Einfeldia austini new species

Male Holotype. Duval County, small creek, sphagnum drainage, near junction of U.S. 1 and U.S. Alternate 1, September 14, 1963. *Paratypes*: Same location and date, two males and four females.

Male. Head light brown, pedicel of antenna ochraceous, flagellum brown, palpi lighter brown; PO bristles multiple, not in one row; frontal tubercles two times as long as basal diameter; thorax light brown with medium brown to ochraceous mesonotal vittae, scutellum and sternum; postnotum almost black; PA bristles three, DL bristles about 10 in single row; halter knob not darkened; wing and veins brown, without macrotrichia, but appearing densely punctate. AR 2.76; WL 1.95 mm.

Abdomen medium brown, paler on posterior borders of segments IV-VI. Forelegs dark brown from middle of femora to apex; middle and hind legs darker toward apex; middle tibia with two spines (one tibia of holotype has three spines, but this is apparently an abberation). LR 1.9-2.0. Genitalia as in Fig. 7g.

This species differs from *E. dorsalis* in having shorter wing length, in the shape of the base of the superior appendage, and the shape of anal point. It differs from *E. natchitocheae* in wing length and details of male genitalia, as well as in immature stages. For comparison, *E. dorsalis* has a WL 3.2 mm, AR 3.0, LR 1.7; *E. natchitocheae* has WL 2.61 (2.39-2.7)mm, AR 3.0, LR 2.2; and *E. austini* has WL 1.95 mm, AR 2.76, LR 1.9-2.0.

Larva (Fig. 7*a-d*). Head capsule pale, occipital rim and teeth of mandible and labial plate dark brown. Labial plate with median trilobed tooth and six laterals, the first and second laterals not completely separated. Premandibles with two broad darkened blades. Antennal ratio 50:24:6:8:3, blade to middle of fourth segment. Anal papillae short with seven long pale bristles.

Pupa (Fig. 7*e-f*). Brown, 5.7 mm long; cephalic tubercles fairly large with preapical bristle. Tergite I bare, II with median longitudinal band of shagreen and posterior row of approximately 60 hooks. Tergites III-V with broad median longitudinal shagreen band; VI with shagreen band narrower, especially in the middle; VII with antero-lateral patches of shagreen, and VIII with an area of fine shagreen on each side of midline; lateral filaments on V-VIII:

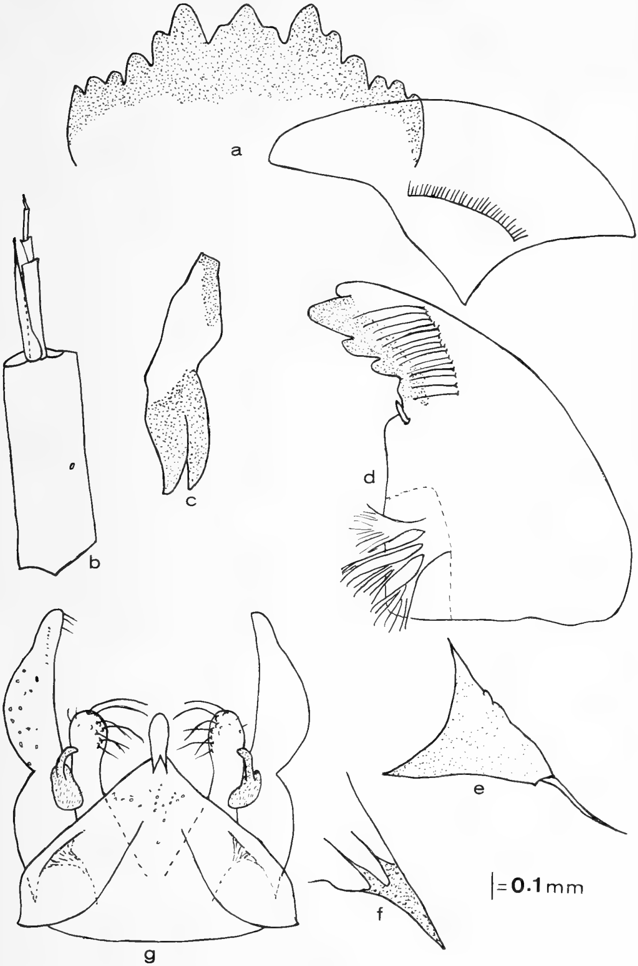

Fig. 7. *Einfeldia austini,* details of larva (*a-d*), pupa (*e-f*) and male genitalia (*g*). *a* labial plate and paralabial, *b* antenna, *c* premandible, *d* mandible, *e* cephalic tubercle, *f* lateral spur of segment VIII.

4-4-4-4; caudo-lateral spur on VIII as in Fig. 7*f*; anal fins with 44 lateral filaments plus a small filament near outer margin, about one-half way from base of fin.

We take pleasure in naming this species for Dr. Oliver E. Austin, Jr., friend and editor, a rare combination indeed.

Acknowledgment

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Quart. Jour. Florida Acad. Sci. 33(1) 1970

Fish Fauna of the Western Caribbean Upper Slope

Harvey R. Bullis, Jr. and Paul J. Struhsaker

The importance of studies concerning offshore benthic marine habitats and associations of animals is gradually being realized. The concept of the marine environment is changing from one of extensive, homogeneous habitats with vague boundaries and randomly dispersed individuals, to one of diverse and well-defined habitats which closely control the composition and distribution of associated faunas. Basic descriptions of these distributions are required as bases for more advanced ecological investigations.

Previously a qualitative and quantitative description of the total upper Continental Slope fish fauna in a tropical region has not been available. It is the purpose of this paper to provide such a description for the western Caribbean Sea.

Although the general nature of the Continental Slope fauna has been known since the early days of modern deep-sea exploration (e.g., Agassiz, 1888), little new knowledge concerning the biology of this major environment has been contributed since the turn of the century. As part of a program to expand the commercial fisheries of the United States, the U. S. Bureau of Commercial Fisheries has conducted exploratory trawling surveys of the upper-slope environment in the Gulf of Mexico and off southeastern United States since 1950. Early findings were encouraging and additional work showed that commercial concentrations of the red shrimp, *Hymenopenaeus robustus,* occurred in the northern Gulf and off southwestern and eastern Florida (Springer and Bullis, 1954; Bullis, 1956; Bullis and Rathjen, 1959; Bullis and Cummins, 1963; Thompson, 1967; and Roe, 1969).

Subsequently, explorations were extended to the Caribbean and Cayman Seas, Bahamas, Greater and Lesser Antilles, and off northeastern South America. These continuing surveys have furnished data for an initial assessment of the upper-slope fauna for most of the tropical western Atlantic between Cape Hatteras, North Carolina and the easternmost tip of Brazil. Some areas of high productivity have been effected off the east coast of Florida in an area 1.6 to 3.2 km wide between 29° and 30° north latitude. In addition to the field records, representative samples of the fauna have been, and are presently, routinely collected and distributed to co-

operating systematists. Results of these surveys and laboratory identifications are incorporated into the automatic data retrieval system of the Bureau's Pascagoula, Mississippi Exploratory Fishing and Gear Research Base. Faunal lists and capture records from all phases of the exploratory fishing program are periodically published (Springer and Bullis, 1956; Bullis and Thompson, 1965). The history and activities of the program have been recently summarized by Bullis (1964).

Two exploratory fishing surveys of the upper slope in the western Caribbean were made by the R/V *Oregon* Cruise 46 in late summer of 1957 and Cruise 78 in late spring of 1962. On the first cruise, field data were incomplete and emphasis was on obtaining extensive qualitative collections of fishes and invertebrates. The identified collections from the first cruise enabled detailed records of species occurrence and abundance to be maintained during the second cruise. These are reported and discussed here.

Study Area

The study area is shown in Fig. 1 along with the locations of the 44 stations evaluated in this report. Observations were made in the 75- to 500-fathom depth range in four general areas; off Rosalind Bank, northern and southern Nicaragua, and western Panama. This is a north-south distance of about 800 km and encompasses most of the western Caribbean.

The Continental Shelf within the northern portion of the area is roughly triangular, narrowing to less than 32 km at the western and southern extremities and broadening to some 200 km between Cabo Gracias a Dios and the northeastern corner.

The shelf proper is a limestone bank, for the most part, with depths from 10-30 fathoms. It is heavily covered with surface or near-surface reefs and many cays (keys) within the 20-fathom isobath. The bottom is irregular and covered with sponge and corals beyond the 20-fathom isobath, making sampling with a trawl, or even a dredge, difficult. Within the 10-fathom isobath are extensive stretches of smooth bottom, consisting mostly of sand and calcareous mud, and here considerable commercial shrimp trawling is conducted periodically.

The shelf edge, or break, varies from 30-40 fathoms below the surface. The bottom to depths of 75-100 fathoms is very rough and

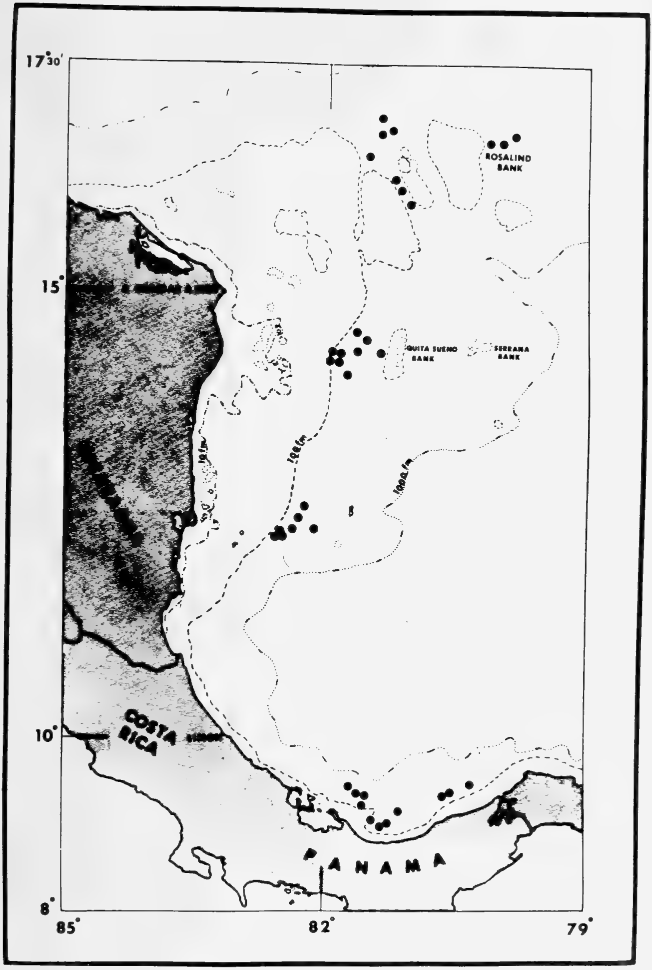

Fig. 1. Study area in the southwestern Caribbean Sea showing positions of trawl stations during R/V *Oregon* Cruise 78. Each dot represents one or more stations.

also generally untrawlable. Along the northern edge of the shelf, the upper Continental Slope has temperature gradients of 3-18C; the distance between the 75- and 500-fathom isobaths ranges from 3.2-2.2 km. A large bank about 56 km long and several small banks, all less than 20 fathoms deep, are connected to the northeastern corner of the shelf by depths of 100-150 fathoms. A 16- to 24-km wide channel with depths of 250 to 400 fathoms separates the large bank from Rosalind Bank to the northeast. Northwest of the channel between the Continental Shelf and Rosalind Bank there is a broad, flat area, seemingly a submarine alluvial fan, of about 100 square km at a fairly consistent depth of 150 fathoms.

South of Rosalind Bank the Continental Slope is broad all the way to about 12° north latitude. The horizontal distances between the 100- and 1,000-fathom isobaths range from 105-39 km, with an average of about 76 km. Within these limits are several large banks and small islands. Serranilla Bank (16°N, 80°W) and Quita Sueno Bank (14°30′N, 81°W) are separated from the shelf by depths less than 500 fathoms. The other major structures, Serrana and Roncador Banks and Old Providence and St. Andrews Islands, are separated from the shelf by depths of 800 fathoms or more. The distance of the 500-fathom isobath from the shelf edge is 63 km at the northern end (15°N), 21 km at 13°30′ north latitude, 51 km at 13° north latitude, and about 13 km off Bluefields, Nicaragua at 12° north latitude. Between 15°N and 12°30′ north latitude the slope gradient is very gentle, ranging from less than 1° to about 4°. The bottom there consists of gray and white mud. The sampling and sounding transects run by the R/V *Oregon* indicate that this area offers several thousand square km of good trawling bottom. South of 12°30′ north latitude the slope is steep and rough, with numerous precipitous faces and gullies to depths of at least 500 fathoms. The bottom is calcareous.

The Continental Shelf in the Golfo de los Mosquitos is narrow, averaging 8-16 km wide, and has a topography and bottom invertebrate fauna similar to the shelf off eastern Nicaragua. The upper slope has a moderate smooth gradient, as off most of Nicaragua, and, in general, no trawling difficulties were encountered.

Temperatures

The western boundary current is the dominant hydrographic feature in the West Indian region. This system is composed of ex-

tensions of the equatorial currents that enter the eastern Caribbean Sea over the Antilles Ridge. The strong, mixed Caribbean current passes through Cayman Sea and the Yucatan Channel, turns easterly and then flows through the Straits of Florida with increased velocity, emerging as the Florida Current. This current follows the southeastern coast of the United States to Cape Hatteras where it leaves the coast, and, with the union of the Antilles Current, it becomes the Gulf Stream. Along the edges of this system numerous eddies develop, especially in the southwestern Caribbean and Cayman Seas and between Jamaica and Cuba. There are also several large, apparently semi-permanent, eddies in the Gulf of Mexico (Sverdrup, Johnson, and Fleming, 1942).

This warm, northerly flowing current has a profound influence on the Continental Shelf fauna of the region and accounts for the northerly extension of established populations of tropical animals into the Gulf of Mexico and to Cape Hatteras at 35°20′ north latitude (Ekman, 1953, p. 46; Cerame-Vivas and Gray, 1966; Struhsaker, In Press). As Cerame-Vivas and Gray point out, these warm, western boundary currents result in the characteristic "trumpet shape" faunal distributions of the tropical regions of the world ocean.

In a different manner, the western boundary current greatly influences the West Indian upper-slope fauna. Because of the density relations within a stratified fluid in motion in the Northern Hemisphere (when looking at a cross-section of the current in the direction it is flowing) the lighter (warmer) water lies to the right of the current and the denser (colder) water lies to the left. This results in a strong horizontal temperature gradient maintained by a cross circulation that advects warm water on the right side of the current, while cold, deep water is brought near the surface on the left side of the current (Dietrich, 1963, p. 535). Thus, the upper slopes of the continental Western Hemisphere have temperatures of 8-12 C at depths of 220 fathoms, whereas temperatures of 14-17C are found at the same depth over the upper slopes of the Bahamas, Greater Antilles, and much of the Lesser Antilles (see Chart V of Sverdrup, Johnson, and Fleming, 1942). Struhsaker (In Press) has pointed out that this results in two natural divisions of the upper-slope environment in the tropical western North Atlantic, which may be termed the Continental Slopes and the Insular Slopes. Exploratory trawling surveys have shown striking differences between

the faunal composition of the two divisions at similar depths. That species common to both divisions occur much deeper over the Insular Slopes is also readily apparent. This effect seems to be exceptionally well demonstrated in the Straits of Florida where the two major divisions of slope faunas of the region occur on opposite sides of the Straits, only about 65 km apart. We hope this paper will provide some basis for the eventual detailed analyses and comparisons of the two faunal divisions.

Normally, bottom temperatures at the 100-fathom isobath of the Continental slopes (hereafter distinguished from the Insular slopes) range between 15-21 C, whereas at 200 fathoms temperatures are from 8-12 C. Eighteen bottom temperatures were obtained during the survey with an experimental minimum temperature recording device that was previously calibrated with a protected thermometer. The results are shown in Fig. 2 along with data on indicated bottom temperatures in the study area from Parr (1937). The resulting bottom temperature profile for the study area agrees well with the temperatures presented by Fuglister (1960) and Stewart (1962) for this region.

Because of the temperature gradients in the western boundary current as mentioned above, the deep permanent thermocline layer (PTL) of the western North Atlantic, is centered at about 200 fathoms here (Struhsaker, In Press). As Fig. 2 shows, the PTL (between about 19-7C) encompasses most of the upper Continental Slope zone in the study area. Although the upper-slope bottom temperatures are below the depth of seasonal influences, Struhsaker (In Press) presented evidence that internal waves in the PTL could effect short-period temperature changes of at least 3 C. He also hypothesized that these temperature changes might effect local changes in the depth distribution of some of the more mobile inhabitants of the upper slopes.

METHODS

The sampling gears used in this study were 12.2 m flat and semi-balloon shrimp trawls (Bullis, 1951). The netting was 5 cm stretched mesh (#18 thread cotton) in the trawl bodies and 4 cm stretched mesh (#42 thread cotton) in the codends. These trawls cover a path 6.7-7.3m wide under usual conditions when spread with 1.8 m trawl doors. Using a single float, the trawl has a vertical opening of about 1.5 m. The footrope rides very lightly on the

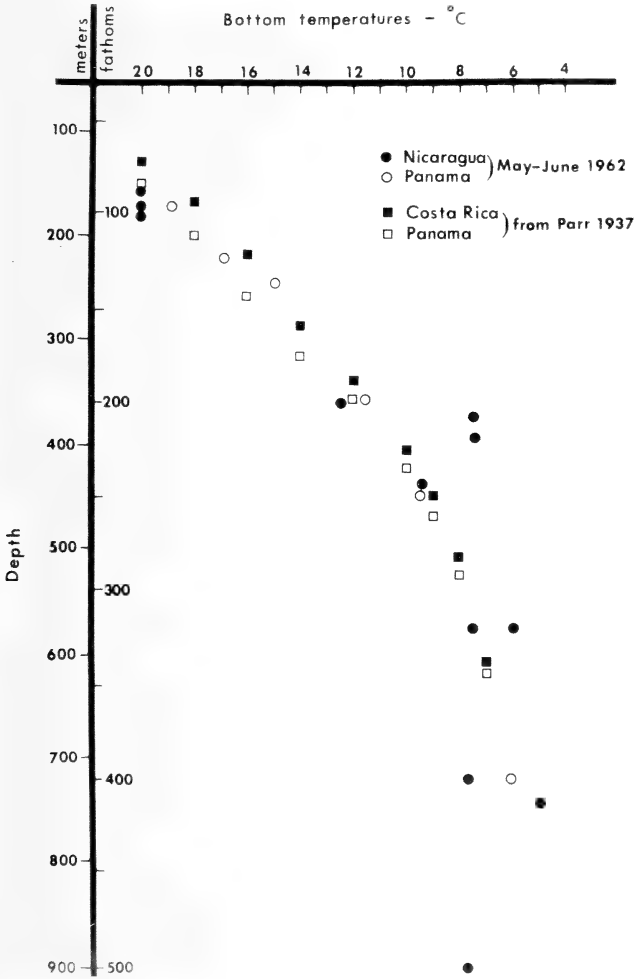

Fig. 2. Bottom temperature profile for Continental Slope depths in the southwestern Caribbean Sea.

bottom and a "tickler chain" attached to the bottom rear corner of each door rides about .6-.9 m in front of the footrope and incites the more active benthos to swim or jump off the bottom into the path of the trawl.

Because of the number of variables involved, quantitative data on animal populations sampled with shrimp trawls can be developed only in very general terms. Sampling periods of 1, 2, 3, and 4 hours were attempted, but frequently they were interrupted because trawling hazards appeared on the depth sounder-recorders. Navigation was by celestial means and loran fixes except in a few cases of radar positioning. We attempted to maintain a constant speed of 2 to 3 knots (1.0-1.4 m/second) but current conditions may have varied the range of speeds as much as ±2 knots (1 m/second) in some areas. Quantifying these data is further complicated because shrimp trawls capture only a portion of the animals in their paths. For example, recent motion picture analyses (unpublished) of shrimp trawl performance by the Bureau of Commercial Fisheries Gear Research Unit, Pascagoula, Mississippi, show that escapement of royal-red shrimp (*Hymenopenaeus robustus*) might be as high as 90 per cent of all shrimp encountered by the trawl.

Despite these difficulties, some attempt must be made to quantify and interpret these observations on the upper-slope fauna to provide bases for more detailed and sophisticated investigations. Until more efficient sampling gears are devised, we feel that analysis of a large number of shrimp trawl samples will provide some of these bases. Because of the known inefficiency of the trawls, all biomass and numerical density figures given in this paper should be considered minimal. To determine the area sampled in each depth range, we assumed an average on-bottom trawl speed of 2.5 knots (1.2 m/second) and average net opening of 7 m, which resulted in a sampling rate of 3.2 hectares per hour.

The amount and distribution of sampling effort and the numbers and weights of fishes taken are shown in Table 1. Fifty-fathom depth intervals were selected as the most practical because of sampling distribution. The number of stations in each 50-fathom depth range varied from 1-9, whereas the number of hectares sampled varied from 9.6-60.8. The 44 trawling stations represent a total of 79.6 hours of on-bottom sampling time during which about 29,700 fishes were captured. At each station the fishes and the crustaceans were sorted from the catch and counted. Lengths and

TABLE 1

Distribution of Sampling Effort, Number of Families, Number of Fish taken, Pounds of Fish taken, Density and Biomass by Depth in the Study Area

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Total no. stations	6	9	8	9	3	4	2	1	2
Total no. hectares sampled	19.2	34.9	60.8	49.6	20.8	30.7	13.1	9.6	16.0
Total no. of families taken	31	36	37	41	33	34	18	8	8
Total no. of fish taken	1827	3967	9796	9451	1838	2176	422	25	174
Average no. of fish/ hectare sampled	95.2	113.7	161.1	190.5	88.4	70.9	32.2	2.6	10.9
Total no. of kgs. of fish taken	150	218	350	418	104	150	45	9	27
Average no. of kgs./hectare	7.8	6.2	5.8	8.4	5.0	4.8	3.4	1.0	1.7

weights were recorded for most species of the readily identifiable fishes. Measurements were made using measuring boards with 0.5 cm units. Extensive zoological collections were made during the survey, most of which are in the collections of the U. S. National Museum and the Bureau's Tropical Atlantic Biological Laboratory, Miami, Florida.

RESULTS AND DISCUSSION

Composition, Abundance, and Distribution. Any attempt to report on a large portion of the slope fauna of the western Atlantic south of 35° north latitude is complicated by the limited taxonomic knowledge of many important groups of animals and lack of identification keys suitable for field use. An extreme example of the unknown nature of the fish fauna in the study area is represented by the Scyliorhinidae (See Appendix I). This family was represented by four forms; *Galeus arae*, a new species of *Galeus*, a new species of *Scyliorhinus*, and an undescribed genus and species. Springer (1965) has since described these forms (See Appendix I). Of three species of chimaeras present, only one, *Hydrolagus alberti*, has been recorded as a member of the western Atlantic fauna. A second species of *Hydrolagus* probably represents what has been considered an endemic of the northwestern Atlantic, and the third an undescribed species of *Neoharriotta* (Bullis and Carpenter, 1966), previously considered a monotypic genus in the eastern Atlantic. Other groups that presented identification problems were the families Congridae, Brotulidae, Gadidae, and Ophidiidae, and the peristediid genus *Peristedion*.

The benthic fishes taken during the survey represent 60 families and an estimated 140 species; however, in the field only about 73 were identified to species, 21 to genera and the remainder to family. All of the batoid fishes were preserved and later identified by William C. Schroeder, Woods Hole Oceanographic Institute. These field and laboratory identifications resulted in a total of 127 species and species groups of demersal fishes, which are listed in Appendix I.

We should state here that we consider all fishes listed to primarily occupy the demersal habitat as adults. Thompson (1963) considers the bathyalbenthic bottom community to be a richly populated ecotonal belt, which grades into the pelagic layers above

and the benthic layers below. The belt is inhabited not only by endemic species, but also occasionally by truly benthic or pelagic animals. Fish inhabitants of this belt are easy to capture in our bottom trawls; therefore, we consider demersal fish species to be not only those that rest upon or burrow in the bottom but also those that are free-swimming but still closely associated with the bottom.

In general composition, some 75 per cent of the identifiable species taken in the study area are widely distributed at similar depths along the Continental Slopes of the tropical western Atlantic region. About 18 per cent of the species appear to be approaching the southern limit of their geographic range; 3 per cent are nearing the northward limit; and the remaining 4 per cent are known only from the southwestern Caribbean. Therefore, 93 per cent of the western Caribbean species are found in the Gulf of Mexico and along the southeastern coast of the United States, whereas only 78 per cent are known from the southeastern Caribbean and off northeastern South America (as derived from available literature sources and extensive unpublished distribution data at the Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi).

The depth distribution and numerical abundance of each family and species group is given in Appendix I. The relative abundance of each family and the bottom temperatures in each 50-fathom depth zone are shown in Figs. 3a and 3b. Families that were present, but comprised less than 1 per cent of all the fishes taken, are shown as a straight line, whereas the dashed line indicates that the family was not represented in that depth range.

Fifteen families were numerically dominant in the study area. Seven of these achieved dominance by the abundance of single species: Caproidae—*Antigonia combatia*; Polymixiidae—*Polymixia lowei*; Triglidae—*Bellator egretta*; Zeidae—*Zenion hololepis*; Grammicolepidae—*Xenolepidichthys dahlgleshi;* Neoscopelidae-*Neoscopelus macrolepidotus*; and Chaunacidae—*Chaunax pictus*. The remaining eight families achieved their dominant status by the occurrence of from 2-14 species.

Upon leaving the shelf, 26 per cent of the families represented in 75-100 fathoms are lost. At 150 fathoms 39 per cent have been lost; 49 per cent at 200 fathoms; 59 per cent at 250 fathoms; and at 350 fathoms 88 per cent have disappeared. Of the remaining four families, one drops out at 400 fathoms, one at 450, and two persist to the limits of the study depths. However, of 31 families found

on the outer shelf (75-100 fathoms), six (Apogonidae, Scorpaenidae, Ogcocephalidae, Brotulidae, Ophidiidae, and Congridae) are composed of diverse species that represent their respective families over a wide bathymetric range, and six additional families (Caproi-

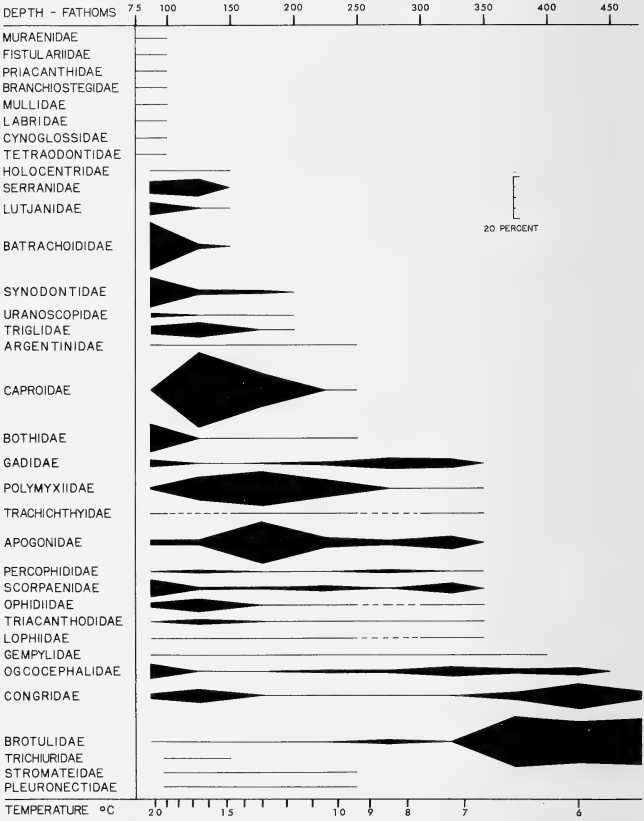

Fig. 3a. Relative abundance of families on the Upper Continental Slope of the southwestern Caribbean Sea as percentage of total fishes sampled from each depth range.

dae, Triacanthodidae, Percophididae, Polymixiidae, Trachichthyidae, and Gempylidae) are shallow-water extensions of families that may be considered as typical inhabitants of the upper Continental Slope.

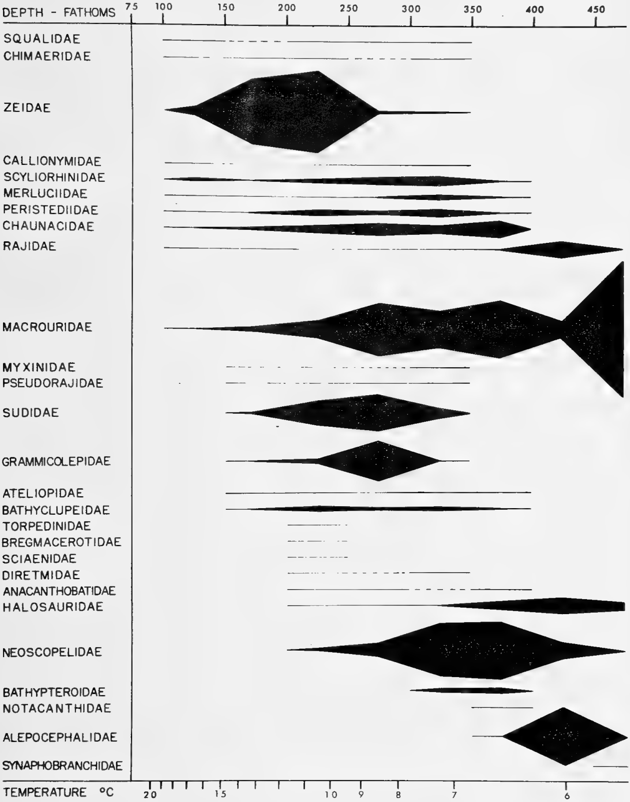

Fig. 3b. Relative abundance of families on the Upper Continental Slope of the southwestern Caribbean Sea as percentage of total fishes sampled from each depth range.

Within the 101- to 150-fathom range, we first find many families that might be considered as typical inhabitants of the upper Continental Slope in the Caribbean region. Nineteen families (Caproidae, Triacanthodidae, Percophididae, Polymixiidae, Anacanthobatidae, Pseudorajidae, Merluciidae, Callionymidae, Scyliorhinidae, Peristediidae, Zeidae, Chaunacidae, Sudidae, Chlorophthalmidae, Myxinidae, Bathyclupeidae, Ateleopidae, Chimaeridae, and Neoscopelidae) were taken in the study area. The four numerically dominant families in numbers of individual fish are the Caproidae, Polymixiidae, Serranidae, and Triglidae, respectively. The last two families are typical shelf inhabitants, with some members (i.e., *Serranus phoebe*, *Bellator* sp.) extending slightly beyond the edge of the Continental Shelf.

In the 151- to 200-fathom range the numerically dominant families are all typically upper-slope groups. Four families make up 83 per cent of the total number of fish taken in these depths: Zeidae (32 per cent), Apogonidae (18 per cent), Caproidae (17 per cent), and Polymixiidae (16 per cent). The typical shelf families decrease in number rapidly.

The zeids are still the dominant family in the 201- to 250-fathom range and comprise 39 per cent of the total number of fishes taken in these depths. In abundance, they are followed by the Sudidae, Macrouridae, and Polymixiidae. This marks the first appearance of sudids and macrourids in any numbers. The Caproidae is poorly represented in this depth range, decreasing rapidly in abundance after being the dominant family in 101-150 fathoms.

The Macrouridae comprise 26 per cent of the fish sampled in the 251- to 300-fathom depth range and assume dominance. Large numbers of grammicolepids are present only in this depth range. The Sudidae remain numerically important and are followed by the first appearance of the Neoscopelidae.

The Neoscopelidae assume dominance (27 per cent) in the 301- to 350-fathom depth range and are followed by the macrourids (18 per cent). Most of the remaining fish caught are more or less uniformly distributed among eight families, six of which were typically upper-slope forms. Beyond 300 fathoms the upper-slope families are numerically less important.

The Neoscopelidae and Macrouridae are still the dominant families (28 per cent) each in the 351- to 400-fathom depth range,

closely followed by the Brotulidae (24 per cent), which makes its first appearance as a numerically important family. The upper-slope families are virtually unrepresented in this depth range where, along with the brotulids, there is the introduction of the Halosauridae, Congridae, and Bathypteroidae as numerically important groups.

In 401-450 fathoms the alepocephalids and brotulids are dominant and, collectively, account for 48 per cent of the fish taken in this depth. Further net "loss" of families in this depth range reduces the total number of families to eight; however, only one station was occupied in that depth range.

Eight families are present in the 451- to 500-fathom depth range, of which the macrourids are overwhelmingly dominant (68 per cent). The remaining seven families are either typically abyssal or are those with wide bathymetric distributions.

Distribution Pattern. The general pattern that emerges from these abundance and distribution data is typical of most animal aggregations. Although many groups are present in an area, the total faunal composition is dominated by only a few taxa. In passing from one depth zone to another, these dominant taxa arise, gain dominance in a particular zone, and then gradually lose importance and disappear. Although records were not kept on the weights of the species and species groups taken at each station, examination of the numerical density data in conjunction with known weight ranges for each group indicates that when a family is among the numerically dominant in a particular depth range, it is usually one of the dominant groups with regard to biomass.

Although there is, in general, a gradual replacement of one dominant group by another from zone to zone, the data of Fig. 3 seem to show two major trends. The first is the disappearance and appearance of many families between 75 and 100 fathoms. The second is the apparent major loss of families in depths greater than 350 fathoms. This effect is further illustrated in Fig. 4 where the total number of families taken in each depth range is given along with the number of families "gained" and "lost" in each depth range when progressing from lesser to greater depths. The net change for each depth range is shown at the top of its column. The total number of families gradually increases from the shelf edge to a high in the 201- to 250-fathom depth range. The number gradu-

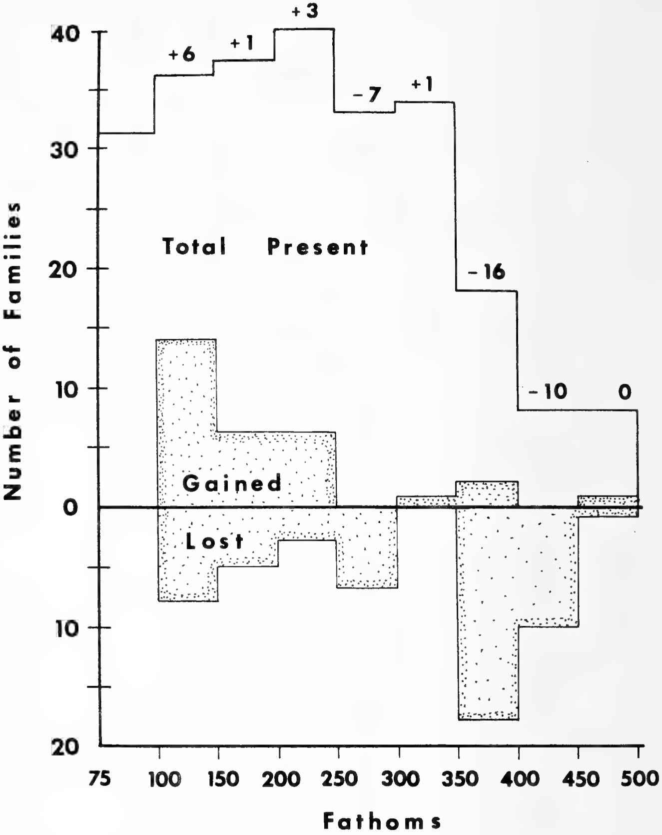

Fig. 4. Total number of families present in each depth range and the number of families "gained" and "lost" in each depth range when progressing from lesser to greater depths. Net change for each 50-fathom interval shown at top of histogram.

ally diminishes in the next two depth ranges, but is suddenly reduced between 351-400 fathoms and 401-450 fathoms.

This pattern is interpreted as follows: upon leaving the shelf, the familial composition of the ichthyofauna undergoes a major

TABLE 2

Estimated Minimum Standing Crop for the Indicated Depth Ranges within the Study Area

Depth range in fathoms	Kilograms/hectare			
	Fish	Crustaceans	Other Invertebrates	Total
75-100	7.8	0.9	3.1	10.9
101-150	6.2	0.3	4.5	11.0
151-200	5.8	1.2	2.0	9.0
201-250	8.4	2.7	1.7	12.8
251-300	5.0	0.9	1.3	7.2
301-350	4.9	1.3	1.5	77.7
351-400	3.5	2.4	0.4	6.3
401-450	1.0	0.0	0.4	1.4
451-500	1.7	0.4	0.7	2.8

change, resulting in an overall gain in families from the outer shelf zone (75 to 100 fathoms). Conditions stabilize in the next few depth ranges: with the small exchange of families that occurs, there is a general increase in the total number of families present to 201-250 fathoms. In the next two depth ranges, however, only one new family is introduced, whereas eight are lost. The great reduction of family numbers between 351 and 450 fathoms is due to the loss of 26 families with only two additions.

The estimated minimal standing crop of fishes within the study area is given in Table 2. The total biomass generally decreases upon leaving the Shelf edge but increases to a peak in the 201- to 250-fathom depth range. Beyond these depths the biomass decreases with depth. Whereas the estimated biomass of fishes follows this pattern, the echinoderms, sponges, and mollusks exhibit a generally decreasing biomass with increased depth. The crustaceans exhibit an increased "standing crop" in the 201- to 250-fathom and 351- to 400-fathom depth ranges. This is probably due partially to quantities of *Hymenopenaeus robustus* and *Nephrops binghami* in the 201- to 250-fathom range and *Plesiopenaeus edwardsianus* in the deeper depth range.

Upper-Slope Association. On the basis of the above data, there appears to be an association of fishes that is characteristic of the upper Continental Slope. The upper limit of this fauna in the 75-

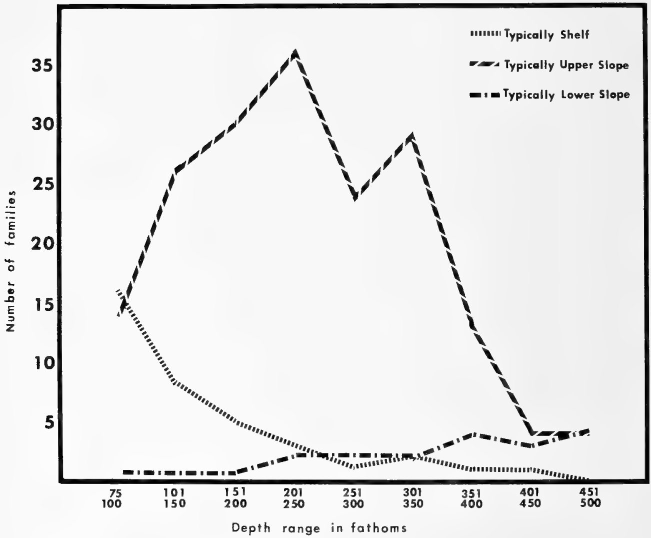

Fig. 5. Numbers of families at descending depth levels considered representative of shelf, upper-slope, and lower-slope ichthyofauna.

to 150-fathom depth range is an exchange area where typically shelf families are replaced by upper-slope families. The lower limit of upper-slope fauna is demarcated by the drastic reduction of total number of families present and replacement of upper-slope families with lower-slope families at depths greater than 350 fathoms. The shelf families are defined here as those that have greatest numerical density in depths between 75-100 fathoms. Upper-slope families are considered to be those that have the greatest density between 101-350 fathoms, and lower-slope families those greatest between 351-500 fathoms. The number of families in each category present in each depth range is shown in Fig. 5. As expected, the number of shelf families greatly diminishes beyond 100 fathoms and none are present in the 451- to 500-fathom depth

range. The lower slope families exhibit a similar trend from greater to lesser depths, reaching a peak number between 201-250 fathoms.

Although we have observed this enriched, distinctive upper-slope fauna in other areas of the tropical western North Atlantic, the data presented here represent the first quantitative analysis of this faunal association. In the western Caribbean, this association is distributed roughly between the 19 C isotherm (100 fathoms) and the 7 C isotherm (350 fathoms). These temperatures delimit the deep, permanent thermocline layer of the western North Atlantic region where it contacts the Continental Slope. There the fauna flourishes at depths of the 10 C isotherm (225 fathoms), diminishing quantitatively and qualitatively above and below this depth over the slope.

Schroeder (1955) reported the results of extensive trawling explorations of the Continental Slope in the western North Atlantic between Delaware Bay and Nova Scotia. About 75 species of bottom fishes were taken at 259 trawling stations in depths of about 50-730 fathoms over a two-year period. Of those species listed for the New England slope, the following eight were also taken in the western Caribbean: *Myxine glutinosa, Argentina striata, Parasudis truculentus, Merluccius albidus, Coelorhynchus carminatus, Zenopsis ocellatus,* and *Urophycis regius* (the last species was taken in the western Caribbean, but is not listed in Appendix I because detailed counts were not maintained for it). Schroeder (1955, p. 366) also presented estimates of the standing crop of slope fishes off New England. A comparison of Schroeder's figures (converted to kg/ha) for that region and our values (Table 2) are as follows: 101-200 fathoms, 17.9 vs. 6.0; 201-300 fathoms, 48.1 vs. 6.7; 301-400 fathoms, 50.4 vs. 4.1; 401-500 fathoms, 36.9 vs. 1.3. These data would indicate that the standing crop of fishes on the slope region of the northwestern Atlantic to be about 3, 7, 13, and 28 times as great as in the Caribbean. These data, however, should be compared only in a very general manner because Schroeder's estimates are based on catches of 18.2 m trawls with 7.6 cm mesh webbing, whereas our estimates are based on catches of 12.2 m trawls with 5 cm mesh webbing. As Schroeder (1955, p. 364) points out, bottom trawl catches seem to increase exponentially with increased trawl size. It thus appears that the New England slope ichthyofauna is richer quantitatively, but poorer qualitatively than that of the western Caribbean, as would be expected.

TABLE 3

Mean Lengths (mm) of Fishes Measured by Depth

Depth range (fathoms) Species	75 100	101 150	151 200	201 250	251 300	301 350	351 400	(n)
Antigonia combatia (TL)	97	121	—	—	—	—	—	(944)
Bathypterois bigelowi (FL)	—	—	—	—	134	118	123	(58)
Bembrops gobioides (TL)	—	—	195	180	193	—	—	(69)
Chaunax pictus (TL)	—	62	102	118	122	130	190	(1275)
Chlorophthalmus agassizi (TL)	—	—	72	136	148	145	—	(574)
Parasudis truculentus (TL)	—	—	161	205	220	—	—	(104)
Coelorhynchus carminatus (SD)	—	—	54	59	65	59	—	(273)
Cyttopsis roseus (TL)	—	—	—	93	110	—	—	(74)
Galeus arae (TL)	—	—	259	277	251	275	—	(344)
Merluccius albidus (TL)	—	—	275	290	365	415	—	(130)
Neoscopelus macrolepidotus (SL)	—	—	—	—	91	94	126	(762)
Nezumia bairdii (SD)	—	—	48	47	56	52	72	(408)
N. hildebrandi (SD)	—	—	—	32	36	—	44	(253)
Parahollardia schmidti (TL)	—	—	112	138	—	—	—	(90)
Polymixia lowei (TL)	97	129	136	153	127	—	—	(1489)
Setarches parmatus (TL)	—	—	86	103	—	127	—	(368)
Synagrops bella (FL)	—	98	125	158	182	167	—	(717)
Xenolepidichthys dahlgleishi (TL)	—	—	95	102	88	—	—	(324)
Zenion hololepis (TL)	—	59	63	78	71	—	—	(635)

TL, total length; SL, standard length; FL, fork length; SD, tip of snout to origin of first dorsal.

Size and Depth. Extensive size-frequency data were taken for 19 species of fishes. They are summarized in Table 3 as mean sizes for each 50-fathom depth range. Species that were selected are readily identifiable and are a major component of the tropical western Atlantic upper-slope ichthyofauna. With a few notable exceptions, such as the peristidiids, ophidiids, brotulids, gadids, and congrids (most present identification problems now) these species represent a rather typical cross-section of the upper-slope ichthyofauna.

Fifteen species (*Chlorophthalmus agassizi, Parasudis truculentus, Neoscopelus macrolepidotus, Nezumia hildebrandi, N. bairdii, Coelorhynchus carminatus, Merluccius albidus, Cyttopsis roseus, Zenion hololepis, Antigonia combatia, Parahollardia schmidti, Polymixia lowei, Setarches guentheri, Synagrops bella,* and *Chaunax pictus*) demonstrate an increased mean size with increased depth. All but *Chaunax* and *Polymixia* have a significant (at the 1 per cent level) linear correlation. A curvilinear relation for these two species is strongly indicated.

The mean lengths of the four remaining species (*Bathypterois bigelowi, Xenolepidichthys dahlgleishi, Bembrops gobioides,* and *Galeus arae*) are nearly constant at all depths. A positive correlation between size and depth was found in *Galeus arae.* However, a complex distributional pattern in this species related to sexual maturity and depth grouping may bias the data toward this relation (Bullis, 1967).

For the most part, each species reaches its greatest density somewhere toward the center of its depth range. Also, species showing a strong size-depth relationship tend to have greater bathymetric ranges than species that do not demonstrate such a relationship.

The direct relation between size and depth has been discussed in detail for *Pleuronectes* in the North Sea, where such differential distribution also varies inversely between size (age) and density (Graham, 1956). Size increase with depth has been shown for several western Atlantic Shelf species by Caldwell (1955, 1957, 1961).

Explanatory Theories. In seeking an explanation for the above data, the modes of reproduction of the species involved were considered. Teleostean species in which the young develop pelagically characteristically spawn large numbers of eggs, whereas species in which the young develop in demersal habitats produce only

moderate to small numbers of eggs (Mead, Bertelsen, and Cohen, 1964). On the basis of these general types of development, the two following hypotheses are given to account for the size-depth relations reported above.

First, species that increase in mean size with increasing depth and decreasing temperatures, and have a broad bathymetric range, produce pelagic eggs and/or larvae. The young of these species are carried various distances along the coasts and may be swept inshore over the Continental Shelves or offshore into oceanic areas. After developing to the pre-juvenile stage, they either descend gradually to some depth or undergo relatively small daily vertical migrations. The depths to which these individuals descend are limited by the temperature tolerances of that species at that particular stage in its life history. Our hypothesis requires that these pelagic young do not descend deeper than the Continental Shelves or the upper end of the species' demersal depth range on the upper slope. Individual pre-juveniles undergoing vertical movements over the shelf and upper slope eventually contact the bottom, but those carried to oceanic areas only descend to certain depths (depending upon the local temperature structure), never contact the bottom and are permanently lost to the primary population. The young of these species that find the bottom relatively quickly move to the habitat of their size and age group, which tends to be at lesser depths than the adults, because they are undergoing a temperature acclimation from the warm, epipelagic environment to the colder, demersal upper-slope environment. During development and maturation in this demersal habitat, young individuals gradually descend to depths occupied by the reproducing segment of the population. A few individuals wander into even greater depths, where decreased temperatures may slow their growth rate but increase their longevity. These latter individuals are the largest, but least numerous members of the population.

The second hypothesis is that species that change only slightly in mean size with depth, and usually occupy a more restricted bathic range, have demersal eggs and larvae or bear their young alive. The young of these species already inhabit the depths and temperatures occupied by the adult segment of the population. Thus, they do not undergo change from a warm, epipelagic existence to a cold, benthonic existence, and become more restricted in

demersal depth ranges while dispersing over the entire bathic range of the population.

Of the 15 species demonstrating a size-depth relation and for which we hypothesize pelagic young, nine are represented by pelagic larvae identifiable to the familial or generic level: Neoscopelidae (implied); *Chlorophthalmus*; and *Chaunax* (Mead, et. al., 1964); Macrouridae (Marshall, 1965); *Antigonia* (Berry, 1959); and *Merluccius* (Bigelow and Schroeder, 1953). Four of the remaining six species (*Synagrops bella, Setarches guentheri, Cyttopsis roseus, Zenion hololepis*) are represented at the familial level by larval specimens taken in epipelagic plankton tows during investigations off southeastern United States by the R/V *Theodore N. Gill.* The families of the two remaining species (*Polymixia lowei* and *Parahollardia schmidti*) have not been recognized in the *Gill* collections, but pelagic berycomorph and plectognath larvae are common (Jack Gehringer and Frederick H. Berry, Bureau of Commercial Fisheries, Biological Laboratory, Brunswick, Georgia, personal communication).

Two of the four species with no size-depth correlation and for which we hypothesize demersal eggs or larvae, are thought to have benthonic young. We assume the scyliorhynid *Galeus arae* to be viviparous (Stewart Springer, personal communication). The deepsea iniomid fishes, which would include *Bathypterois bigelowi* under consideration here, produce a relatively small number of eggs that develop on or near the bottom (Mead, et al., 1964). The two remaining species, *Xenolepidichthys dahlgleishi* and *Bembrops gobioides,* may be considered as negative evidence supporting the above hypotheses since grammicolepid and percophidid eggs and larvae have not been recognized in the *Gill* epipelagic plankton collections (J. Gehringer and F. Berry, personal communication).

In the slope environment, size-depth relations appear influenced by two factors: vertical movements of population segments of species having planktonic eggs and larvae; and the physiological response of all populations to the direct relations of depth and temperature in slower growth, increased age, and greater maximum size with increased depth.

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APPENDIX I

Depth Distribution of Fish Families and Species in Average Density of Individuals per Hectare

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Myxinidae			*.02*	*.02*		*.10*			
Myxine glutinosa			.02	.02		.10			
Scyliorhinidae		*1.31*	*1.21*	*2.78*	*3.37*	*3.13*	*.08*		
Galeus arae			1.05	2.57	2.84	3.03			
Galeus cadenati				.13	.53	.10	.08		
Scyliorhinus hesperius		.11	.05	.08					
Schroederichthys maculatus		1.20	.11						
Squalidae		*.17*		*.34*	*.05*	*.55*			
Etmopterus bullisi						.36			
E. schultzi				.06	.05	.03			
E. virens				.22		.07			
Centrophorus granulosus				.02					
C. uyato						.03			
Squalus cubensis		.17		.02		.03			
S. blainvilli				.02		.03			
Torpedinidae				*.02*					
Torpedo nobiliana				.02					
Rajidae		*.17*	*.41*	*.74*	*.20*	*.64*	*.31*	*.21*	*.06*
Raja lentigenosa		.17							
R. teevani						.03			
Breviraja colesi						.06			
B. spinosa			.21	.16	.10				
Cruriraja poeyi				.22					
C. rugosa				.18	.10	.52		.21	

APPENDIX I (Cont.)

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Gen., sp. indeter.			.20	.18		.03	.31		.06
Pseudorajidae			*.15*	*1.33*	*.24*	*.23*			
Pseudoraja atlantica			.15	1.33	.24	.20			
P. fischeri						.03			
Anacanthobatidae				*.46*	*.19*		*.31*		
Anacanthobatis americanus				.46	.19		.31		
Chimaeridae		*.06*	*.02*	*.08*		*.20*			
Hydrolagus alberti		.06		.04		.20			
Neoharriotta carri			.02	.04					
Argentinidae	*.16*	*1.15*	*.99*	*.85*					
Argentina striata		1.15	.51	.85					
Gen., sp. indeter.	.16		.48						
Alepocephalidae							*.31*	*.73*	*.06*
Muraenidae	*.05*								
Gymnothorax ocellatus	.05								
Congridae	*2.14*	*6.08*	*.31*	*.36*	*.29*	*.49*	*1.22*	*.31*	*.44*
Synaphobranchidae									*.13*
Synaphobranchus kaupi									.13
Halosauridae				*.32*	*.38*	*.39*	*1.37*	*.20*	*.38*
Notacanthidae							*.08*		
Notacanthus analis							.08		
Synodidae	*13.91*	*1.66*	*1.97*						
Sudidae			*1.57*	*23.03*	*15.05*	*3.42*			
Chlorophthalmus agassizi			.71	20.26	14.42	3.42			
Parasudis truculentus			.86	2.77	.63				

APPENDIX I (Cont.)

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Bathypteroidae					*.48*	*1.76*	*.99*		
Bathypterois bigelowi					.48	1.50	.38		
B. viridensis							.61		
Bathypterois sp.						.26			
Neoscopelidae				*2.34*	*6.06*	*19.14*	*9.40*	*.21*	*.06*
Neoscopelus macrolepidotus				2.34	6.06	19.14	9.40	.21	.06
Ateleopidae			*.07*	*.02*	*.10*	*.03*	*.08*		
Ijimaia antillarum			.07	.02	.10	.03	.08		
Gadidae	*3.23*	*.14*	*.02*	*2.12*	*4.17*	*2.51*			
Macrouridae		*.20*	*3.94*	*18.26*	*21.93*	*12.78*	9.39	*.31*	7.39
Steindachneria argenteus		.20	.49	2.20	.24	.10			
Coelorhynchus caribbaeus			1.09	.79					
C. carminatus			.90	2.59	4.09	.52			
Nezumia bairdii			1.46	6.30	4.38	8.70	.23	.10	.38
N. hildebrandi				2.22	8.70	1.89	.76		.63
Trachonurus sulcatus						.13	.38	.10	.31
Oxygadus occa							.23		.06
Gadomus longifilis					.14	.36	.38		.75
G. arcuatus							.31	.10	
Bathygadus vaillanti				.04	3.03	.13	.92		1.31
B. favosus									2.63
B. macrops									.44
Hymenocephalus sp.				4.12	1.35	.95	6.18		
Cariburus sp.									.88
Bregmaceriidae				*.04*					

APPENDIX I (Cont.)

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Bregmaceros atlanticus				.04					
Merluciidae		*.09*	*.05*	*1.58*	*.24*	*1.53*	*.08*		
Merluccius albidus		.09	.05	1.58	.24	1.53	.08		
Fistulariidae	*.05*								
Fistularia tabacaria	.05								
Polymixiidae	*1.09*	*12.74*	*26.23*	*15.47*	*.14*	*.03*			
Polymixia lowei	1.09	12.74	26.23	15.47	.14	.03			
Trachichthyidae	*.05*		*.02*	*.59*		*.03*			
Hoplostethus sp.	.05		.02	.59		.03			
Holocentridae	*.26*	*.03*							
Myripristis jacobus	.26	.03							
Diretmidae				*.02*		*.26*			
Diretmus argenteus				.02		.26			
Zeidae		*3.24*	*51.74*	*73.94*	*1.40*	*.78*			
Zenion hololepis		2.90	50.95	72.40	.87	.62			
Cyttopsis roseus		.20	.54	1.52	.53	.16			
Parazen pacificus		.14	.25						
Zenopsis ocellatus				.02					
Grammicolepidae		*1.15*	*2.85*	*17.32*	*.10*				
Xenolepidichthys dahlgleishi		1.15	2.85	17.32	.10				
Caproidae	*.36*	*41.73*	*26.83*	*.06*					
Antigonia capros	.10	.23							
A. combatia	.26	41.50	26.83	.06					
Bathyclupeidae			*.02*	*3.41*	*1.44*	*1.11*	*.08*		
Bathyclupea argenteus			.02	3.41	1.44	1.11	.08		

APPENDIX I (Cont.)

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Serranidae	*5.64*	*9.01*							
Serranus phoebe	.89	.03							
Unidentified	4.75	8.98							
Lutjanidae	*7.09*	*.95*							
Lutjanus vivanus	1.30	.03							
Pristipomoides aquilonaris	.68								
Unidentified	5.11								
Priacanthidae	*.26*								
Pseudopriacanthus altus	.21								
Priacanthus arenatus	.05								
Apogonidae	*2.50*	*4.58*	*28.48*	*10.08*	*3.85*	*4.24*			
Synagrops bella	.36	4.38	9.26	7.02	1.97	.75			
Synagrops sp. 1			19.06	.61					
Synagrops sp. 2		.20	.16						
Epigonus pandionus				.65		.49			
Unidentified sp. 1	2.14								
Unidentified sp. 2				1.80	1.88	3.00			
Branchiostegidae	*.42*								
Caulolatilus sp.	.42								
Sciaenidae				*.02*					
Mullidae	*.21*								
Pseudupeneus maculatus	.05								
Unidentified	.16								
Labridae	*.16*								
Percophididae	*.21*	*1.51*	*9.1*	*.79*	*.97*	*.62*			

APPENDIX I (Cont.)

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Bembrops maculatus		.80	.10	.08					
B. anatirostris		.71	.05						
B. gobioides			.76	.06	.87	.13			
B. magnisquamis				.65	.10	.49			
Bembrops sp.	.21								
Uranoscopidae	*2.29*	*.17*	*.05*						
Kathetostoma cubana	2.29	.17	.05						
Gempylidae	*.26*	*1.09*	*.62*	*1.25*	*.34*	*.19*	*.08*		
Gempylus serpens				.91	.34	.16			
Epinnula o. americana	.26	1.09	.60	.22					
Unidentified sp.			.02	.12		.03	.08		
Trichiuridae		*.03*							
Scorpaenidae	*7.55*	*1.87*	*1.85*	*4.14*	*.10*	*3.26*			
Setarches guentheri			1.13	4.08	.10	3.26			
Unidentified sp.	7.55	1.87	.72	.06					
Triglidae	*4.32*	*8.38*	*.34*						
Bellator brachychir	3.80	1.78	.21						
B. militaris	.16	.29							
B. egretta		6.11							
Prionotus stearnsi		.20	.13						
Prionotus sp.	.36								
Peristediidae		*.89*	*.90*	*4.36*	*2.31*	*2.54*	*.31*		
Callionymidae		*.03*	*.15*	*.04*	*.05*	*.07*			
Callionymus agassizi		.03	.15	.04	.05	.07			
Brotulidae	*.21*	*.11*	*.21*	*.73*	*.72*	*1.08*	*8.16*	*.52*	*2.38*

APPENDIX I (Cont.)

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Ophidiidae	*3.18*	*6.37*	*.51*	*.63*		*.07*			
Stromateidae		*.09*	*.02*	*.06*					
Cubiceps nigriargenteus?		.09	.02	.06					
Bothidae	*12.14*	*1.10*	*.11*	*.12*					
Citharichthys cornutus	7.92	.12							
Gastropsetta frontalis	.10								
Cyclopsetta fimbriata	.21								
Chascanopsetta sp.			.03						
Unidentified	3.91	.98	.08	.12					
Pleuronectidae		*2.15*	*2.64*	*2.18*					
Cynoglossidae	*.05*								
Symphurus sp.	.05								
Triacanthodidae	*.31*	*1.67*	*.80*	*1.31*	*.05*	*.46*			
Hollardia hollardi	.31	1.61	.30						
Parahollardia schmidti		.06	.38	1.29	.05	.46			
Johnsonina eriomma			.12	.02					
Tetraodontidae	*.16*								
Sphoeroides sp.	.16								
Batrachoididae	*20.05*	*2.93*							
Porichthys porosissimus	20.05	2.93							
Lophiidae	*.26*	*.11*	*.05*	*.10*		*.06*			
Chaunacidae		*1.71*	*6.18*	*12.00*	*5.43*	*5.35*	*.23*		
Chaunax pictus		1.71	6.18	12.00	5.43	5.35	.23		
Ogcocephalidae	*6.61*	*.29*	*.58*	*2.18*	*1.01*	*3.81*	*.84*	*.10*	
Halieuthichthys aculeatus	4.84	.17							

APPENDIX I (Cont.)

Depth range (fathoms)	75 100	101 150	151 200	201 250	251 300	301 350	351 400	401 450	451 500
Ogcocephalus parvus	1.61	.03	.07						
Ogcocephalus sp.	.16	.06	.08						
Dibranchus atlanticus		.03	.43	2.18	1.01	3.81	.84	.10	

Exoerythrocytic Gametocytes of Saurian Malaria

Sam R. Telford, Jr.

The genus *Plasmodium* and the family Plasmodiidae are characterized by these features: "a sexual phase in the mosquito, and asexual cycles in tissue and blood cells of the vertebrate host; gametocytes are produced and are confined to mature erythrocytes. Malaria pigment is present in certain stages of the parasite" (Garnham, 1966, p. 65). Recent studies of saurian malarial species have provided exceptions to this classical definition. *Plasmodium mexicanum* of California lizards can complete sporogony and thus accomplish the sexual cycle in psychodid sandflies (Ayala and Lee, 1970). Two species of otherwise typical malarial parasites in Panamanian lizards apparently lack pigment in all stages (Telford, 1970). Findings reported here further indicate the necessity for taxonomic re-evaluation of the malarial parasites at both family and generic levels.

During study of approximately 500 malarial infections in Panamanian lizards, unpigmented gametocytes of at least three *Plasmodium* species were found occasionally in white blood cells of four host species, *Thecadactylus rapicaudus* (Gekkonidae), *Anolis biporcatus, A. poecilopus*, and *A. lionotus* (Iguanidae). Study of 58 malarial infections in Costa Rican lizards revealed exoerythrocytic gametocytes in *Anolis limifrons* and *A. aquaticus*.

An exoerythrocytic infection in an *Anolis biporcatus* was present at capture 1 April 1968 and persisted until death on 26 June 1969. Trophozoites, schizonts, and gametocytes of both sexes were seen in occasional thrombocytes throughout this period and increased significantly in abundance in the two months preceding the hosts death. An erythrocytic infection of *Plasmodium floridense* was present also at capture and until death, but often disappeared during the observation period.

All exoerythrocytic gametocytes observed in the Panamanian and Costa Rican anoles were in cells indistinguishable from thrombocytes (Figs. 3, 5-7). Those found in several geckoes, however, were confined to apparent lymphocytes (Fig. 9). Relationship of the exoerythrocytic parasites to the erythrocytic infections present in all hosts is not certain. *Anolis biporcatus* is commonly parasitized by *P. floridense* and *P. tropiduri*, often in mixed infec-

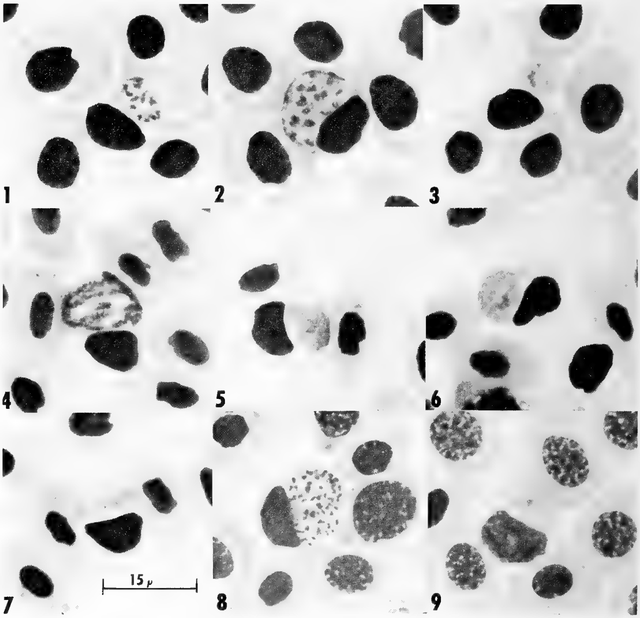

Fig. 1, 2, *Plasmodium* schizonts in thrombocytes of *Anolis lionotus*. Fig. 3, Macrogametocyte in thrombocyte of *A. lionotus*. Fig. 4, Schizont in thrombocyte of *Anolis biporcatus*. Fig. 5, 6, Macrogametocytes in thrombocytes of *A. biporcatus*. Fig. 7, Microgametocyte in thrombocyte of *A. biporcatus*. Fig. 8, Schizont in lymphocyte of *Thecadactylus rapicaudus*. Fig. 9, Macrogametocyte in lymphocyte of *T. rapicaudus*.

tions; *A. lionotus* and *A. poecilopus* share infection by *P. balli* and a smaller species which is probably *P. tropiduri*. A very different *Plasmodium* sp. parasitizes *T. rapicaudus*. The exoerythrocytic gametocytes of the anoles are almost identical in appearance among themselves (Figs. 3, 5-7) and are similar to those in the geckoes (Fig. 9), but the lymphocytic schizonts of *T. rapicaudus* (Fig. 8) contain many more nuclei than do those in anole thrombocytes (Figs. 1, 2, 4). The recently described haemosporidian genus *Saurocytozoon* from white cells of Brazilian lizards (Lainson and Shaw, 1969), in which only gametocytes were found, possibly represents a comparable phase of yet another saurian malaria.

Two interpretations are possible at present: (1) The exoerythrocytic forms represent one or (probably) more malaria-like species which parasitize white blood cells exclusively or (2) These stages are part of the mechanism whereby latent infections can again give rise to patent parasitemia of the erythrocytes. Further study of living infections is necessary for correct interpretation of the exoerythrocytic gametocytes, but it is already obvious that saurian malarias differ significantly in their biology from their relatives among the Aves and Mammalia.

ACKNOWLEDGMENTS

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Hyla andersoni in Florida

STEVEN P. CHRISTMAN

THE pine barrens tree frog, *Hyla andersoni* Baird, has been reported from the Atlantic coastal plain in two widely disjunct areas, the pine barrens of New Jersey and central North Carolina (Gosner and Black, 1967). Neill (1947) reported it from Richmond county in eastern Georgia.

On the evening of March 30, 1970, I collected a single specimen of *Hyla andersoni* in the western panhandle of Florida, near Dorcas, Okaloosa County. The frog was taken on state highway 393 at 1900 hrs. CST. On August 16, 1970, Bruce Means collected two additional specimens at the same locality.

The possibility of taxonomic distinction exists. Gosner and Black (1956) reported significant differences between the New Jersey and North Carolina populations, but did not name them. This new locality is approximately 580 airline miles from the North Carolina population, and 350 from the eastern Georgia record. Investigations to determine zoogeographic and possible taxonomic significance of *Hyla andersoni* in Florida are underway.

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Vegetational Changes in the National Key Deer Refuge

Taylor R. Alexander and John H. Dickson III

The Key deer, *Odocoileus virginianus clavium* Barbour and Allen, is a distinct geographic race that inhabits the southernmost Keys of Florida (Barbour and Allen, 1922). Today they are restricted to the Keys within the National Key Deer Refuge that was established in 1954. According to the U. S. Fish and Wildlife Service pamphlet, RL-518 (1965), only about 50 deer existed in 1957 and the future of the herd was in doubt. The herd estimate in 1965 was 300. It is now (1969) estimated at about 400.

Prior to the establishment of the Refuge, the junior author began an extensive study of the deer and the Keys they inhabited. The published reports (Dickson, 1955; Dickson, Woodbury, Alexander, 1953) contain the first ecological study of the deer habitat on a Key-by-Key basis. Big Pine Key was found to be the Key most used by deer and the northern part of this Key is in the Refuge.

When the original study was started in 1951, a prominent feature at the north end of Big Pine Key was an open grass prairie measuring one-half mile in length and one-fifth of a mile in width. There was limited evidence of its use by deer. A few small shrubs were scattered throughout the area. It was bounded on the east by a mangrove community and on the west by a community of West Indian broad leaved trees and shrubs. The soil was a shallow marl in contrast to the rocky surface of most of the Key. Local reports and physical evidence supported the belief that the prairie had been farmed in the past. Fires had been of common occurrence prior to 1951 and served to maintain the grasses and suppress the shrubs. The Refuge was put under strict fire control, and by the summer of 1967 it was apparent that an extensive vegetational change had occurred.

The study now reported was made in June of 1968 to determine the exact nature of the floral and vegetational changes between 1951 and 1968 in the prairie area and to evaluate them in terms of potential effect on the deer population.

METHODS

Thirty quadrats, 3 × 10 feet, were studied. An attempt was made to randomly sample the area and follow procedures previously reported (Dickson, 1955), so that the current data could be compared directly with those of 1951. Plant names, numbers, heights and per cent of cover were determined. The last was recorded as four classes: 1 (less than 1 per cent); 2 (1-5 per cent); 3 (5-25 per cent), and 4 (25-50 per cent). Frequency figures are the percentage of quadrats in which a species occurred. Density values are the average number of individuals per quadrat. Counts for trees and shrubs were converted to plants per acre. Species found in 1968 but not in 1951 were noted. Plants browsed by deer were also noted, based on information determined in 1951 from stomach and pellet analyses, and direct observations. Plant names used are from the checklist of Lakela and Craighead (1965).

RESULTS AND DISCUSSION

Comparison of data in Tables 1 and 2 shows that the number of species doubled in the sixteen-year period between the studies. This diversification was characterized by a shift favoring woody species. The most spectacular species change involved *Sporobolis virginicus* that had a frequency drop from 100 to 40 and cover class from 4 to 2. In 1951 this grass gave the area its characteristic appearance of a grassland. The change appears to be related more to an indirect shade-effect from young trees and shrubs than a direct response to fire control. Observations indicate the species has very little shade tolerance. Loss of this species is not likely to directly effect the deer, since there is no record of its being browsed. Reduction in the dense grass cover makes the habitat less fire-prone. *Sporobolis* has been replaced by several grasses and sedges that have different growth habits and do not cover the ground so completely. For example, *Abildgaardia monostachya,* a sedge not found in 1951, was common in 1968.

Less change occurred among the semi-woody species that were important in 1951, *Randia aculeata, Morinda roioc, Waltheria amer-*

Fig. 1. Upper 1951 photograph; Lower 1968 photograph. Note growth of *Eugenia myrtoides* on the right of the jeep track.

icana and *Solanum blodgettii*. The change in importance of woody species was due largely to invasion by new species. It is the rapid growth of these invading species that changed the appearance of the habitat so dramatically (Fig. 1).

Of the known deer food species, *Bumelia celastrina* and *Pithecellobium guadelupense* increased and *Acacia peninsularis, Agalinis maritma, Cassytha filiformis, Chamaesyce scoparia* and *Ximenea americana* all decreased. Those showing very little change were *Conocarpus erecta, Morinda roioc, Neptunia pubescens, Ran-*

dia aculeata and *Solanum blodgettii.* It is recognized that our knowledge of the plants used as food by these deer is incomplete at this time. It is very likely they make use of many of the invading species.

Data in Table 3 show the extent of change caused by the invasion of woody species. They also indicate that succession had advanced toward the climax community of plants of West Indian affinity (Alexander, 1958, 1967). These species existed along the west edge of the prairie in 1951. Propagules were available in quantity. All that was needed, apparently, was freedom from fire

TABLE 1

1951 plant list and analyses

Species	Frequency	Density	Cover
Sporobolus virginicus	100	—	4
Chamaesyce scoparia	90	13.1	2
Randia aculeata	90	7.5	3
Grass (unidentified)	80	6.9	3
Flaveria linearis	70	1.8	2
Morinda roioc	70	3.3	2
Waltheria americana	60	7.6	2
Solanum blodgettii	50	2.9	2
Agalinis maritima	40	1.9	2
Cassytha filiformis	40	0.4	1
Chloris petraea	40	0.9	2
Evolvulus alsinoides	40	0.5	1
Borrichia frutescens	30	4.8	1
Physalis angustifolia	30	0.6	1
Acacia peninsularis	20	0.6	3
Conocarpus erecta	20	0.2	2
Cynanchum blodgettii	20	0.3	1
Pithecellobium guadelupense	20	0.8	2
Setaria geniculata	20	0.8	2
Sideranthus megacephalus	20	0.2	1
Andropogon sp.	10	0.2	2
Bumelia celastrina	10	1.1	2
Croton linearis	10	0.1	1
Neptunia pubsecens	10	0.1	1
Passiflora pallida	10	0.1	1
Piscidia piscipula	10	0.1	1
Portulaca phaeosperma	10	0.4	1
Ximenia americana	10	0.1	2

TABLE 2

1968 plant list and analyses

	Frequency	Density	Cover	Not found in 1951	Deer Food
Paspalum blodgettii	76.6	11.8	2		
Morinda roioc	76.6	3.9	1		*
Randia aculeata	73.3	7.9	3		*
Flaveria linearis	73.3	4.4	1		
Abildgaardia monostachya	63.0	5.1	2	*	
Solanum blodgettii	56.6	3.9	2		*
Waltheria americana	56.6	3.3	1		
Chamaesyce scoparia	53.3	1.6	1		*
Fimbristylis castanea	50.0	3.9	1		
Andropogon gracilis	40.0	3.6	1		
Sporobolus virginicus	40.0	2.3	2		
Pithecellobium guadelupense	33.3	0.8	2		*
Andropogon glomeratus	33.3	0.6	1		
Agalinis maritima	26.6	0.9	1		*
Croton linearis	26.6	0.8	1		
Conocarpus erecta	26.6	0.5	3		*
Cassytha filiformis	26.6	0.3	1		*
Chiococca alba	26.6	0.3	1	*	
Sideranthus megacephalus	23.3	5.7	1		
Bumelia celastrina	23.3	1.0	2		*
Cassia bahamensis	23.3	1.0	1	*	
Polygala grandiflora var. leiodes	23.3	0.3	1	*	
Evolvulus alsinoides	20.0	0.9	1		
Eugenia myrtoides	20.0	0.6	2	*	
Byrsonima cuneata	16.6	0.3	2	*	
Metopium toxiferum	16.6	0.3	2	*	
Physalis angustifolia	13.3	0.3	1		
Aristida purpurascens	13.3	0.1	1		
Coccoloba uvifera	13.3	0.1	2	*	
Sporobolus domingensis	10.0	2.3	1		
Setaria geniculata	10.0	0.2	1		
Reynosia septentrionalis	10.0	0.3	1	*	
Acacia peninsularis	10.0	0.1	1		*
Passiflora pallida	10.0	0.1	1		
Eugenia longipes	6.6	0.06	1	*	
Neptunia pubescens var. floridana	6.6	0.06	1		*
Rhacoma crossopetalum	6.6	0.06	1	*	

TABLE 2 (cont.)
1968 plant list and analyses

	Frequency	Density	Cover	Not found in 1951	Deer Food
Thrinax microcarpa	6.6	0.06	1	*	*
Cynanchum blodgettii	6.6	0.02	1		
Melanthera parvifolia	3.3	0.5	1	*	
Eustoma exaltatum	3.3	0.3	1	*	
Borrichia arborescens	3.3	0.1	1	*	
Borrichia frutescens	3.3	0.1	1		
Chloris petraea	3.3	0.1	1		
Stachytarpheta jamaicensis	3.3	0.1	1	*	
Rhacoma ilicifolia	3.3	0.06	1	*	
Spartina spartinae	3.3	0.06	1		
Ipomoea sagittata	3.3	0.03	1	*	
Jacquemontia pentantha	3.3	0.03	1	*	
Jacquinia keyensis	3.3	0.03	1	*	
Manilkara emarginata	3.3	0.03	1	*	
Piscidia piscipula	3.3	0.03	1		
Serenoa repens	3.3	0.03	1	*	
Urechites lutea	3.3	0.03	1	*	
Ximenia americana	3.3	0.03	1		*

for seedling establishment. Changes in height of the woody species was very striking. In 1951 the shrubs and young trees were not over 2 feet tall and most were under 1 foot. By 1968 these were in the 4-12 feet range. There were areas where impenetrable thickets were forming and approaching the conditions present in the mature climax stands of mature subtropical forests on Big Pine Key.

It is characteristic for these woody species to grow thickly and self-prune their lower branches, leaving very little good browse within reach of the deer. The mature subtropical forest interior is not a good feeding place, although deer do bed down here. It is reported that deer respond best to browse plants in early stages of succession or to those of fire-type communities (Vogl, 1967). Fire keeps woody plant browse within reach of the deer. Komarek (1966) discussed means of keeping vegetation as it is or adjusting it by use of fire for the best support or production of wildlife. Robertson (1953) in discussing fire on marl glades stated that fire kills back seedlings of woody plants that have become established between fires and thus acts to slow the invasion of shrub vegetation into the glade.

TABLE 3

Evidence of change toward typical subtropical hardwood forest 1951-1968

Species	'51 Typical Forest			'68 Northern Prairie			'51 Northern Prairie		
	Freq. %	Cover	Plants Per Acre	Freq.	Cover	Plants Per Acre	Freq.	Cover	Plants Per Acre
Randia aculeata	85.7	2	2,744	73.3	3	11,470	90.0	3	10,890
Metopium toxiferum	80.0	3	2,702	16.6	2	436			
Reynosia septentrionalis	74.3	3	1,682	10.0	1	436			
Thrinax microcarpa	60.0	3	489	6.6	1	87			
Pithecellobium guadelupense	54.6	3	2,214	33.3	2	1,162	20.0	2	1,162
Eugenia axillaris and *myrtoides*	45.7	2	2,030	20.0	2	871			
Bumelia celastrina	40.0	2	555	23.3	2	1,452	10.0	2	1,597
Piscidia piscipula	40.0	3	240	3.3	1	44	10.0	1	145
Manilkara emarginata	31.4	2	191	3.3	1	44			
Byrsonima cuneata	22.9	2	99	16.6	2	436			
Eugenia longipes	22.9	2	439	6.6	1	87			
Coccoloba uvifera	14.3	1	83	13.3	2	145			
Jacquinia keyensis	11.4	1	58	3.3	1	44			
Coccothrinax argentea	8.6	1	83						
Rhacoma crossopetalum	8.6	1	34	6.6	1	87			
Ximenia americana	8.6	2	91	3.3	1	44	10.0	2	145
Serenoa repens	2.9	1	8	3.3	1	44			

Parts of the marl prairie area had been control-burned in March of 1968, three months before the present study was done. The fire had killed the tops of many of the woody species. However, root-sprout recovery was in evidence everywhere in the burn. Ground cover plants had also recovered. Apparently no plant species had been eliminated. There were deer tracks and groups of pellets, indicating use of the burned and near-by unburned shrubby areas. As a deer habitat, the combination of burned and unburned areas seems an improvement over the open grass prairie of 1951.

The old prairie area of northern Big Pine Key is too limited in size to support many deer. This is true of the entire range available to these deer. Human pressure is increasing daily and reducing the amount of land outside the Refuge that is available to the deer. As the deer are pressured into less space than they are now using, careful management of the vegetation in the Refuge is paramount. This study done in a tropical environment documents the rapidity with which parts of the Refuge area can change under total fire protection. The other vegetation types in the Refuge are being studied to determine change since the 1951 study. Data from these show that a considerable difference in rate of change characterizes each of the various Key habitats and suggest that different control procedures be carefully evaluated for each vegetation type within the Refuge.

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Shell Debris and Shoreline Energy on Florida Gulf Beaches

Herbert M. Austin

During the last 50 years several systems of coastal classification have been proposed. Johnson (1919, *fide* Shepard 1963) classified coasts as submergent, emergent, neutral, or compound. Shepard (1963) classified coastal areas by the agents acting upon them: Primary coasts being those acted upon by terrestrial agents, and secondary coasts those under the influence of marine processes. Price (1953, fide Tanner 1960), characterized Florida's coastal environments by energy levels, using ramp angles as a first approximation. Tanner (1960) classified Florida's coastal regions according to their respective energy levels. He approximated energy levels by using Helle's (1958) surf statistics and interpolating between points of observation. This treatment divides coasts into zero, low, moderate, and high energy environments.

The zero energy environment, as defined by Tanner, is characterized by mud, marsh grass, and no turbulence. A low energy

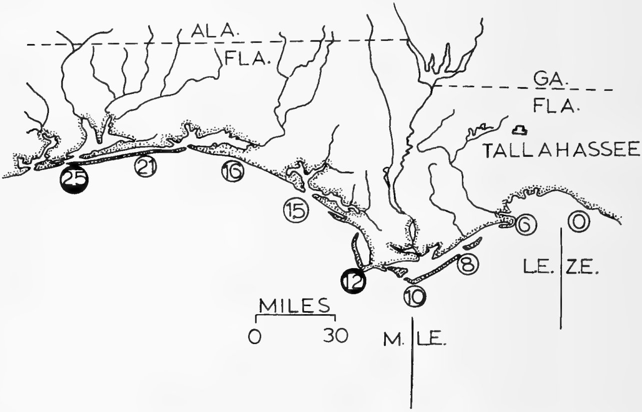

Fig. 1. Variations in energy levels along the Florida Panhandle coast (see text for discussion of symbols). Adapted from Tanner (1960). M, moderate; LE, low energy; ZE, zero energy.

beach has average annual breaker heights up to 10 cm, followed by the moderate energy environment with an average breaker height of 10-50 cm. The high energy environment experiences average breaker heights of over 50 cm.

Visual observations at a given time are often not sufficient to estimate the energy level on a specific beach, although one can usually differentiate between a zero-energy and a high-energy beach. Low to moderate energy shores grade into each other, however, and are hard to differentiate. It is equally difficult to assign a qualitative energy value to a beach. Energy expended on a beach reduces the size of certain organic materials such as molluscan shells and shell debris. Therefore, the size of the shell debris, other factors being equal, should be an indicator of relative energy levels.

This paper is a description of a technique by which the energy level and average breaker height may be estimated by study of the unconsolidated shoreline substrate material and provides an alternate, but complementary method to that developed by Tanner (1960), for estimating relative energy levels.

PROCEDURES

A sample of the substrate from the high tide swash mark was collected at each of the locations in Table 1. This sample was fractioned by sieving under running water.

The fractions were separated by 5 mm groupings: 1-5, millimeters, 6-10, 11-15, and so on. Each fraction was weighed and the modal size class was established by the weight percentage. The modal classes were correlated geographically, and the energy levels as established by Tanner (1960). A multiple-variance regression analysis was carried out at the Florida State Computer Center using stepwise regression (Dixon, 1968). The correlation coefficient was determined for the modal size of shell hash debris versus energy, and longitude.

RESULTS

Table 1 lists the modal frequency distribution of shell and shell-hash sizes from the collection sites. When possible, collections were made at the locations where Tanner had established energy values. These values are shown when applicable.

TABLE 1

Collection data

Collection sites	Values*	Size†	Longitude
1. Dekel Beach	0	36–40mm	83°49′W
2. Shell Point	not available	31–35mm	84°18′W
3. Alligator point	6	16–20mm	84°22′W
4. Central street St. Georges Isl.	not available	6–10mm	84°51′W
5. Cape San Blas	12	1–5 mm	85°23′W
6. Mexico Beach	not available	1–2 mm	85°25′W
7. West Panama City Beach	15	6–10mm	85°55′W

*Average annual breaker height, after Tanner (1960).
†Hash, modal size

Figure 2 is a graphic representation of the modal frequencies plotted against Tanner's energy levels. With the exception of Panama City Beach the average shell-fragment size decreased as the energy increased. The computed correlation coefficient was −0.925 which indicates that a significant inverse relation exists between hash size and energy at the 99 per cent confidence interval. As the energy level increases, shell fragments show a correlated decrease in size. The correlation coefficient (−.867) between shell size and longitude also shows an inverse relationship at the 99 per cent confidence level.

Figure 3 shows the relation between shell size and longitude. Two breaks may be noted in the slope of the curve, one at Alligator Point, and the other at Cape San Blas.

DISCUSSION

Linear extrapolation between two points of measured physical parameters is at best an inprecise method for predicting average conditions of sea state. The prediction of average breaker heights by extrapolation between two points of measurement, over 100 miles apart, does not show possible rapid changes that may occur between the points. The studies of Tanner, discussed above, involved such interpolations and may in theory have inaccuracies. The data presented here, however, indicate that his conclusions may have more validity than would be predicted.

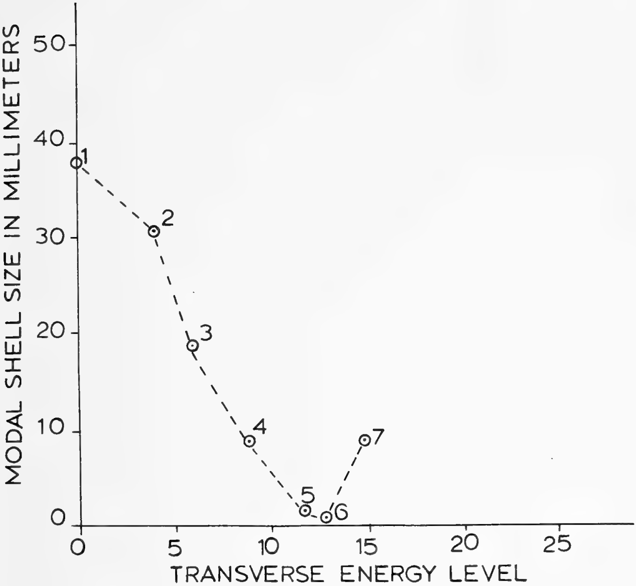

Fig. 2. Relation between modal shell size and Tanner's energy levels (see Table 1 for numbered locations).

The decrease in shell-hash size is inversely correlated to increase in breaker height. From zero, through the lower half of the moderate energy environment, the coasts exhibit large offshore infaunal pelecypod populations, characterized by oysters (zero-energy environment) *Crassostrea sp.*, and cockels (low to moderate environment) *Dynocardium sp.* The higher level, moderate energy to high energy beaches, are in turn, typified by different benthonic population assemblages. The predominant pelecypod there is *Donax sp.* which lives in the turbulent zone and whose shells constitute the major percentage of the carbonate fraction of the beach substrate. On a higher energy beach the source of the shell material is within the zone of deposition, whereas in lower energy environments the shell source is offshore from the zone of deposition.

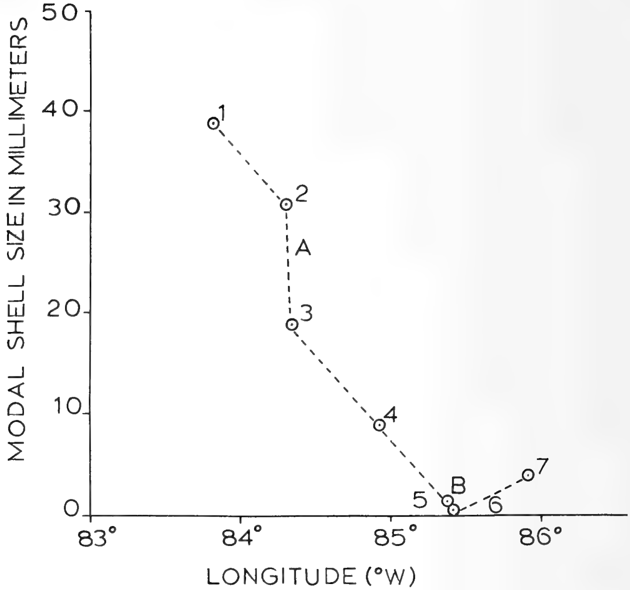

Fig. 3. Relation between modal shell hash and longitude (see Table 1 for numbered locations).

Figure 3 shows two breaks in the slope of the line, both of which occur along spits. Break *A* is at Alligator Point, and *B* at Cape San Blas. This indicates the non-linearity of the increasing wave energy, and the importance of spits, in terms of focusing energy upon small areas of shoreline.

CONCLUSIONS

The linear extrapolation of natural phenomena between widely spaced coastal points of measurements may be inaccurate due to topographic anomalies. The sampling of a form of semi-permanent feature may alleviate this inaccuracy. The use of shell debris from the high tide swash mark, along zero through moderate-energy

coasts, is a potential technique by which the average breaker height for a shore may be estimated, when actual wave data are not available.

Changes in the energy at any given moment may be large. The short-term effects of tides and winds may cause fluctuations over so short a period of time as two hours. The beach substrate, however, does not reflect the short-term variations, and is a more stable indicator. Meteorological tides will, of course, disrupt this pattern, which will eventually re-establish itself.

The collection of shell hash from various low to moderate energy coastal sites where no long-term breaker data are available will allow, with a reasonable degree of accuracy, the approximation of average breaker heights (Table 2).

TABLE 2

Shell hash size relation to predicted breaker height

Shell fragment size in mm	Predicted average breaker height in cm
>36 mm	0
26—35 mm	1— 5 cm
16—25 mm	6— 8 cm
6—15 mm	9—11 cm
1— 5 mm	12—13 cm
< 1 mm	14—15 cm

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Charles E. Russell and the Root Mission to Russia, 1917

Donald H. Bragaw

The decision to send a special Presidential commission to Russia to convey the best wishes and encouragement of the United States to the new democracy was urged upon President Woodrow Wilson by several prominent persons. Secretary of State Robert Lansing thought that it would be appropriate since other Allied nations were either proposing the same, or had already dispatched commissions of their own. The principal concern of the Allies was to make sure that Russia would remain in the war against Germany.

The problem of selecting the right combination of men to serve on the commission occupied both Wilson and Lansing on and off for an entire month commencing on April 11th. Wilson's conversations with Colonel Edward House had apparently led House to suggest a group of men of no particular diplomatic distinction, but representative of various elements of our society. While Wilson adopted House's idea of representative men from various segments of American life, he and Lansing rejected most of the suggestions. In his correspondence with Lansing, Wilson described the men he wanted:

> Men of large view, tested discretion and a sympathetic appreciation of just what it is they have been sent over for . . . besides, that they should look the part. . . . We must find the right men, and they must not all be Democrats,—need not any of them be Democrats,—but should all be genuinely enthusiastic for the success of the revolution.

He later announced his intention of considering appointing a Socialist to the Commission who might not only represent labor, but appeal as well to the Socialist members of the new government. Wilson was opposed, however, to appointing any radical Socialists who might be against the war. He was to finally select a moderate who was as sympathetic to the cause of labor, as he was committed to the war (Papers Relating to the Foreign Relations of the U.S., Lansing Papers, 1920; Russia, I., 1918).

The Commission as finally selected was, perhaps, the most incongruous group possible in terms of the original criteria. The only consistent qualification applicable to all was that they might look the part. It was a commission which most authorities agree was doomed to failure from the beginning by the very nature of its com-

position. While House, Lansing and Wilson had originally agreed on Samuel Gompers to represent labor, Wilson was finally convinced that Gompers was too anti-Socialist to be a welcomed representative from the United States. Charles Crane, the plumbing magnate, was already in Russia due to previous interest, and was chosen as someone whom the present government in Russia already knew, and accepted. The choice of Dr. John R. Mott, the Executive Director of the Y.M.C.A., was an innocuous one which could offend no one. He had been involved in developing Y.M.C.A. recreational programs for soldiers on the Western front. As a representative of business, Wilson finally chose Cyrus McCormick, a choice dictated largely by the knowledge which the Russians presumably had about the harvester machines. To talk with the Russians about financial matters, Lansing recommended, and Wilson acceded to S. R. Bertron, a New York banker who had previously taken a role in the peace negotiations concluding the Turco-Italian War. For the military, Wilson selected the Army Chief-of-Staff, an old warhorse and Indian campaigner, General Hugh L. Scott, and to investigate naval conditions, Admiral James Glennon. These men were all perfectly capable, and some even met the Wilsonian qualifications. In addition to their appearance they were all believers in democracy, and presumably, in the success of a democracy in Russia. They, like Wilson, made no differentiation among varieties of democracy, and so could quite easily fulfill the general criteria (Kennan, 1956; Williams, 1952; Mayer, 1964; Warth, 1954; Russell Diary).

The remainder of the Commission was especially controversial, both in Russia and the United States. Wilson, apparently acting upon William McAdoo's suggestion, had Lansing sound out Elihu Root to be the Chairman of the Mission. Root, albeit reluctantly, accepted this call to serve. The selection of Root, like so many of the other appointments, is shrouded in conjecture. If, as I have concluded, it was McAdoo who suggested him, then there is a strong likelihood that political considerations played the major role. To examine Wilson's criteria, i.e., a firm believer in the revolution, militated against every conservative breath and utterance of Elihu Root. Wilson's almost total ignorance of the Russian situation is his only excuse for appointing Root, or, indeed, the entire commission. Root was a perfect foil for both the German agents and radical agi-

tators busy in Russia undermining the Provisional Government. The anti-war Socialists in this country were enraged. Root was the personification of the Socialist phrase: "tool of Wall Street," and an aristocrat of democratic capitalism. He was the man who even Charles Edward Russell had once condemned in violent language as being the lackey of the corporate interests of Wall Street (Kennan, 1956; Jessup, 1938; Russell, 1908).

Despite his distinguished service in both the War and State Departments, Root was a most inappropriate selection on all counts as a commissioner to a new Socialist democracy, dedicated to the service of the laboring class: Root was just not that kind of a democrat.

To represent labor, Wilson chose James R. Duncan, a Gomper's recommendation. He, too, was a poor choice. Duncan, Vice President of the American Federation of Labor (he was second in command to Gompers), was well past his prime (he was 72), and while honored by the laboring men of America, he was held in little regard as a representative spokesman for labor. This was, perhaps, insulting to the Russian proletariat in the government, who looked to their fellow laborers for strength and assistance. It was not so much that Duncan was unrepresentative of American labor; it was more a matter that there were so many others in the movement who were more reflective of the spirit of the working masses. Duncan, while never as publicly vocal as Gompers, was as anti-Socialist as his chief (Kennan, 1956).

Having once decided to add a Socialist to the Mission, Wilson did not find it easy to select one. When Gompers had been asked for suggestions, he had quickly recommended his good friend William English Walling, a pro-war Socialist, who then received an invitation from Wilson to join the Mission. Walling declined with what apparently was little or no explanation. It is probable, since he was quite familiar with events in Russia, that he realized that he would not be wholeheartedly welcomed, especially by those Socialists who were agitating for an end to the war. Whether it was Gompers or Walling who then recommended Russell is not clear; but in the first days of May, Secretary of Labor William Wilson sounded Russell out as to his availability and apparently got a green light. President Wilson issued, on May 10th, a formal invitation to Russell, which Russell immediately accepted. In such a manner was the last member of the Mission chosen. There is no reason

given for the selection in any of the correspondence, but several considerations are fairly obvious. Russell was a Socialist moderate. President Wilson was, again, misled by his lack of understanding of the Socialist Party split, both in Russia and in America. Russell was also an advocate of the war. Additionally, he had not made any recent appraisals or attacks on the Provisional Government, and was in total sympathy with the revolution, perhaps the only one on the Mission who was unreservedly so. What is more, Russell had a reputation which even Walling did not possess as a firm supporter of movements for the common good—supposedly one of the prime objectives of the new government in Russia. Probably the most persuasive reason for his selection, was his willingness to go (there were only a very few pro-war Socialists from which to choose), and to go on such short notice (*New York Times*, 1917).

Russell's ready acceptance should not be interpreted as a willingness to become a mere "tool" of the Wilson administration. His ready acquiescence to Wilson's call was his individual response to serve mankind in any capacity which would aid in successfully concluding the war with an Allied victory. Russell is again afflicted with his ever present desire to perform a service for man, regardless of its consequences to either himself or to the Mission. In either case it was probably a mistake. For himself, he was vilified with abuse by the anti-war Socialists to whom he was sent to appeal, his repudiation by his own party complicated, and in large measure defeated, his work for the Mission.

Wilson's mission when completed represented a predominance of the "aristocratic" and Wall Street interests which was the tack quickly assumed by the Socialist press. Root, McCormick, Crane, S. R. Bertron, a powerhouse of conservative, reactionary opinion in the United States, were not well chosen to deal with the more radical members of the new government. If, indeed one of the purposes of the Mission was to persuade the government to remain in the war, it was to the more radical members of the Council of Workers, Soldiers and Peasants (the Petrograd Soviet) that the group would have to appeal. No record exists that any of these men ever did. Dr. Mott's concern was with ways in which the Y.M.C.A. and other organizations might make the military service of the Russian soldiers more palatable, encouraging them to continue to fight. Both General Hugh L. Scott and Admiral Glennon

were old staff officers whose concern was to determine the efficiency of the Russian fighting forces, to urge the Russian commanders on to greater effort, and to recommend ways in which the United States could fulfill the needs of the Russian military. Aside from James Duncan and Russell, then, there were really no Mission members who could, or would, appeal to the elements of the Russian society essential for continuing the war (*New York Times*, 1917; Mock and Larsen, 1939).

But the composition of the Commission was only one of its drawbacks. The nature of its arrival and its accommodations were heavily larded with symbolic overtones. The Commission travelled across Siberia from Vladivostok on the Imperial Train, Russell occupying Princess Tatiana's suite, and the others as royally suited. Even Russell indicated that the people at some of the stations looked askance at the train, and on one occasion attacked it, believing that Czar Nicholas II was attempting to return to Petrograd and to power. While it is fairly certain that the Provisional Government wanted to treat the Commission to the best possible transportation, there can be little doubt that some of the Government's ministers, and much of the radical membership of the Council of Soldiers, Peasants and Workmen, realized the impact which might be made by such a display. The "capitalists" from America were thus brought into unfortunate association with the old regime: capitalism was linked with the extravagance and luxury of a monarchy which had been overthrown just two months previously (Russell Diary, 1917).

On their arrival in Petrograd, the Commission was once again linked to the autocratic Czar by being housed in the Winter Palace. While my conjecture here is tempered by the Provisional Government's respect and regard for the comfort of the Commission, it can not be overlooked that this Palace was the very same one from whose balconies the Black Friday massacre had occurred. The palace remained largely untouched from the Czarist occupation, and except for the hospital which now was housed in the lower floor, the Commission was served as royalty had always been served in this palace. Russell, aware always of the aesthetic nature of his surroundings, was quite taken with the artistic treasures: furniture, paintings, sculpture and the like, that abounded throughout these quarters. It may also have been significant that the Provisional

Government and the Soldier's, Peasant's and Worker's Council was located at the other end of the city (Beatty, 1919; Russell Diary).

Russell was much annoyed at the formality of the presentation of their credentials; they were required by American protocol to don their full regalia, while Terestchenko, the new government's foreign minister was dressed in "sackcloth." The reversal of positions, as represented by Benjamin Franklin's arrival in Paris in 1776, seemed to cry out to Russell that the Mission looked "as if we expected the Czar to return." Russell constantly criticized the British representatives and the resident American colony for reflecting the view that without the Czar, Russia will "go smash." "The English idea is, of course, that no country without a king can keep faith, do business, or bake bread." While this represented a recurrence of Russell's anti-British feeling, some Britons and Americans expressed this view openly, and to Russell's mind did much to defeat the Allied aim of keeping the Russians in the war. Thus, the connection of the United States to the British monarchy, and the regalia, which had since Franklin's day taken on greater opulence, only emphasized the symbolic connection to the "old Russia" (Beatty, 1919; Russell Dairy).

Opposition to the Mission began before the Commissioners left the United States. Some of the more vituperative objections came because of Russell's appointment, occurring as it did amid the clamor concerning the Stockholm Conference. This so-called "peace" conference had been originally called by the neutralist Dutch Socialists, and then seized and promoted by the peace-oriented Petrograd Soviet. They hoped to embarrass the predominantly pro-war Provisional Government by forcing them into taking a stand. Thus, even before Russell had been appointed to the Mission, he had taken a position against the holding of the conference opposed to that taken by the very people to whom the President desired that he talk. On top of that, two days before Russell left with the Mission he and his fellow pro-war Socialists issued another broadside at the peace feelers of May, 1917. They declared in ringing tones that it was "useless to strive for peace unless the conditions of peace included the ousting of the Kaiser" and the autocratic government which presently controlled Germany. Needless to say, the National Executive Committee of the Socialist Party replied in a direct blast at Russell. They reported that they had

asked him not to go to Russia, but now that he was determined to do so, they repudiated him as a representative of American Socialism. This, according to the report, was cabled to the Russian Socialists, with the additional remark that "Socialists in America do not presume to advise Russian Socialists in what only they know what is best to do." From Russia came communications from the Socialists there indicating that they did not feel that either Duncan or Russell truly represented American Labor, indeed, no labor organization had ever selected them. The fact that the conservative *New York Times* came to their defense in an editorial recommending government censorship of such anti-government remarks did not help their standing either at home or in Russia (Warth, 1954; *New York Times*, 1917).

More forceful demonstrations of antagonism awaited the Mission on their arrival at Vladivostok, where, after a none too enjoyable voyage, the group was first greeted by a hostile group which treated them as unwelcome intruders. When the official reception committee arrived, they hustled the Mission off to a waiting train which was stationed at a railroad siding immediately adjoining the wharf. After the group had hurriedly left the city, the Russian interpreters who accompanied them, explained that there had been fear of violence being committed against the persons of the Mission. It was also rumored that the train would be blown up somewhere en route to Petrograd. While none of these things did occur, the Mission was ever aware of the possibility; whenever they approached a station it was difficult to tell whether the waiting crowd would be friends or foes. On the return trip, the same conditions prevailed, but on at least two occasions actual events did take place: an attempt to set the train afire, and the blowing up of a bridge just ahead of their train which presumably was intended to finish them. Both Russell and General Scott labelled these threats as the work of anarchists, those who would take advantage of the unsettled conditions to wave their black flags. Despite these threats, the Mission remained remarkably calm, and apparently did not take any deeper meaning from them other than as isolated acts of anarchy. Despite these extraordinary evidences of hostility the group's report to Secretary Lansing did not treat them as reflective of any significant feeling within Russia (Russell Diary; Beatty, 1919).

On the voyage from Seattle to Vladivostok the Commission had met daily to plan their strategy. It was determined that each representative would attempt to communicate with appropriate officials and economic groups as suited his specialty. Thus, while realizing that his job was made difficult by the actions of the Socialists at home, Russell's mission was to seek out the Socialists and talk earnestly with them concerning the prosecution of the war. Additionally, Russell was assigned, largely at his own suggestion, the role of developing a publicity and propaganda program for the aims of the Mission. The first task of meeting with the Socialists was difficult at first, but eventually Russell was accepted by some of the Social Revolutionaries, and moderate Socialists. He was never to achieve a rapport with the radicals, although he did accidentally meet Leon Trotsky on one occasion, and the two had a brief, but pleasant encounter. His view of Lenin at this stage was patronizing but cautious; he was a leader of an exceptionally small radical group, seemingly well-organized and perceptive of Russia's weaknesses, and tinged with pro-German feelings. It must be stressed that only Russell, of all the Mission members, attempted in any way to reach, and to enter into dialogue with, the "masses" of the Russian people through the Council of Soldiers, Peasants and Workmen. It was only through Russell's persistence that James Duncan was allowed to speak before the Petrograd Soviet (Russell Diary; Kennan, 1956; Lasch, 1962).

The matter of publicizing the need for the Russians to remain in the war was a great deal more difficult than Russell had initially imagined. The problems of interpreters and good translations were but two of several handicaps to the program. On the train from Vladivostok to Petrograd, Russell, with Major Stanley Washburn's assistance, mapped out a vast propaganda campaign by which the great masses of Russian people might be reached. Both Russell and Washburn were convinced that this was the key: that if only the people can know the real reason for the war (the preservation of democracy) could Russia be induced to continue in it. Apparently the remainder of the Mission thought initially that this was an excellent idea, and suggested that the Mission request a large appropriation from the State Department for such a program. It should be noted that this was Russell's immediate evaluation of the Mission's opinion. Later diary entries of his seem to modify this

view, for Russell refers constantly to his seeming inability to communicate his "message" to Ambassador David Francis, and the Mission members. This became increasingly true as time passed. The attrition of interest may only have been a reflection of the Mission's dismay over a lack of State Department support for the commission's work. On the other hand, Rene Dosch-Fleurot, a reporter for the *New York World,* was convinced that Russell was considered by many members of the Commission as being a "radical crank." Thus these later entries may well support the "crank" thesis. Frequently, when the Commission assented to a Russell suggestion, it was done grudgingly, and sometimes with acerbity. The Commission's meetings were not all harmonious and Russell seems, on occasion, to have been a thorn in its side. His attempt to show the Mission members the true picture of the political line-up was generally ignored; his insistence that a propaganda campaign such as he had outlined was the only way in which the Allies could counteract the superlative German agents, the "Ambassadors from Hester Street," and the radical Bolsheviks, in their agitation for a separate peace, was not met with complete understanding. The reality of the situation in Russia did not seem to penetrate too deeply with the other members. Russell concentrated his efforts on convincing Duncan of this, but even Duncan did not evince too much interest or concern. On several occasions Russell came into direct conflict with Elihu Root, and apparently made the mistake of conveying this disagreement to Ambassador Francis who, on one occasion at least, seemed cowed by Root's importance. Ambassador Francis' correspondence with Lansing would suggest that he and Root were of one mind that Russell was causing, and would continue to cause, a great deal of friction with the Provisional Government—which both Root and Francis kept insisting was the real base of power in Russia (Russell Diary; Lasch, 1962).

Russell's inveterate activism and his sincere belief in the cause of the Revolution led him into an immediate attempt to make the necessary contacts to carry out his part of the mission. Algernon Lee's tale of Russell immediately setting out to find Bessie Beatty of the *San Francisco Bulletin* to obtain a piece of red cloth of some kind so as to identify himself with the revolutionaries' cause, verges on cariacature. This is just the way that Lee would have the

apostate Russell appear. In reality Russell probably did ask her for the cloth, for such was the sincerety of his belief in the "Red" cause. Russell was fully aware of the adverse press which he had received in Russia prior to the Mission's arrival; it was important for him to establish some kind of rapport with the Social Revolutionaries, a dominant force in the Petrograd Soviet. Bessie Beatty did report going with him to the Soviet to speak when he wore a flaming red necktie and a red rosette in his coat lapel. He had found his symbols and was in the process of implementing their meaning. This type of action on Russell's part was neither unusual nor was it out of character. It also apparently paid off: he did get into the Soviet, he did make a speech to it (however badly translated), and he was able to work with some of the members of that group on several projects. What Lee wanted to overlook, and Christopher Lasch seems to disregard in his work on Russian-American Relations, was that the prevailing power in the Soviet, as in the Provisional Government, was with the moderate Socialists. The Bolsheviks held only a little over 100 seats in a 900-member parliament. Indeed, Russell was not accepted by the Bolsheviks (it should be added that he made no real effort to be accepted by them), but it was his feeling that his work, and that of the Mission, was best advanced through the power that existed at that time, to negate the vocal minority groups. When William A. Williams and Lasch indicate that Russell was the only one to recognize the significant power that existed in the Soviet, it must be stressed that that power at the time was the moderate revolutionaries, not the radicals under Lenin or Trotsky, despite their vocal superiority. Russell was well aware that one of the forces against which he was pitted were the Bolsheviks; they were against continuing the war, indeed, any war, and he knew it. It was his job to convince the wavering and less radical revolutionaries that only the defeat of Germany would assure a peace that would allow Russian democracy to flourish. His publicity program was to be geared to strengthening these elements of the government. The failure to do so would enable the radicals to gain strength, and perhaps force the Provisional Government to accede to the withdrawal of Russia from the war (Russell Diary; Hillquit Papers; Lasch, 1962; Beatty, 1919).

All of the Soviets wore their red badges proudly: rightists, middle-of-the-roaders, and leftists within the revolutionary spec-

trum. The red rosette in his coat lapel was Russell's mark of approbation for the principles of the Revolution. Russell's walks along the Nevsky, and in the Field of Mars where the revolutionaries spoke the magic words of freedom, linked always with peace, made him realize the intensity of the feeling which pervaded the masses. It was not a separate peace with Germany which was desired; but rather, peace, the universal ideal. Only under such a peace could the Revolution be saved, and its principles effected. It seemed an almost unanimous feeling on the part of all of the revolutionaries, regardless of their position on the political spectrum: it was a discouraged Russell who returned from such walks to learn of the continued lack of response from Washington to his propaganda proposals (Russell Diary).

Whatever the discouragements, and there were some days of utter dismay, Russell unrelentingly plugged at the publicity campaign. His tireless, but unrewarded efforts were prodigious. He spoke with many of the press representatives of the Allied nations, sounding them out, and getting their opinions, and their assistance for translations, interpretations, and the like. He contacted and worked with the British propaganda efforts (which he thought were essentially self-defeating: the films they showed of the British Army in action revealed enormous casualties and destruction) in getting publications translated into the vernacular and published. It was extremely embarrassing to Russell to have to rely upon the British to finance the printing of a Root speech which he thought would be of exceptional propaganda value. He talked at great length to Ambassador Francis (whose dissimulation during the entire Mission stay with regard to Russell is revealed in his letters to Lansing) and he was fairly optimistic that Francis seemed to understand the need for publicity. On several occasions Francis sympathetically pretended to send cables to various persons requesting their assistance to the Mission's publicity program; the telegrams may well have been sent, but went through the State Department which delayed, or ignored, them. Russell does not acknowledge in his dairies that he ever received replies. Russell was forced in the end, on the day before leaving Petrograd for the journey home, to turn the publicity efforts over to the Ambassador. It is typical of Russell's optimism even at this point, that he believed that Francis would carry out the plan (Russell Diary).

But the Department of State was the real culprit in holding up the publicity program. Russell's recommendation to the mission of widespread newspaper, journal, pamphlet and film saturation of the need for the united democracies to defeat the autocratic Germans, was finally sent to the Department after a brief delay (one of the incidents which should have revealed to Russell Root's lack of enthusiasms since the latter had held off for two days sending the cable). The reply from the State Department when it came was noncommital and evasive; the report was being studied, and a decision would be forthcoming. The decision was never made, and Russell's insistence on pushing the publicity program at the commission meetings began to wear on the other members. Finally, on July 2, seven days prior to their return to America, Root indicated that the mission would abandon the propaganda program since apparently Lansing and the State Department did not want to do anything about it. In effect, then, Russell's role was eliminated. But Russell deeply felt that he could not allow the decision to be final. At the meeting of the Commission on July 6, Russell astounded the group by proposing that "he remain behind and work on propaganda and publicity." In a revealing diary entry, which, I believe, lays bare the Mission's true feelings toward Russell, feeling which Russell himself may have finally realized, the answer was final:

> Root, of course, delivered the verdict of the rest. It was somewhat acid and to the effect that the Commission could not entertain any such suggestion . . . and declared in a bitter way that the Commission was done with the subject of publicity, which was now up to Francis and the State Department.

Russell then posed the question: suppose that Ambassador Francis asked that he stay? There was no reply. "What if I stayed on my own?" Root, with some irritation, indicated that it would have to be as an individual, and not as a representative of the United States Government. Russell was disheartened; his earlier request to Lansing to be allowed to remain after the Commission had gone, had met with stony silence. There seemed little alternative: he was under orders, and unless the State Department released him from those orders he felt obliged to follow them (Russell Diary).

The situation in Washington at this time was apparently quite complicated. Lansing and Wilson still had not determined just what course should be followed regarding the Revolution. Requests

by the Mission for huge loans to the Provisional Government were met with more silence, since it could not be determined whether it would be either diplomatically or politically profitable to do this.[1] The request for funds for a propaganda and publicity program were greeted in the same manner: procrastination and indecision. Lansing had forwarded the recommendations of the Commission to George Creel for the Committee on Public Information's evaluation. Creel summarized the Commission's reports for Wilson, and at the end of the summary indicated that no detailed plan was ready. But he was already thinking in terms of such a program and the man he wanted to head it in Russia:

> . . . it is my thought to ask Charles Edward Russell to act for the Committee in Russia. He knows more about the Russian situation than any other, and in addition to his sympathy and understanding, he is one of the best newspapermen in the country, and a writer of rare ability.

In spite of this apparent endorsement, Russell was not to be allowed to stay in Russia (Creel Papers).

The Creel Committee never began to act or to put together a viable program until September or October, 1917, when it engaged Arthur Bullard to pursue almost the same program which Russell had suggested in June. Bullard's efforts at the later time were utterly unfruitful, since by that time the radicals' propaganda program had begun to make the successful claim that peace was obtainable, and desirable. It is doubtful that even had the Russell program of publicity gone into effect as early as June that any appreciable difference would have been made. But had the effort been made, there might have resulted a truer understanding of the revolutionary sentiment on the part of the State Department. Certainly the Russian people might have more clearly understood the idealistic and evangelical Wilsonian policies. The press and the popular assemblies never really conveyed the fact that Wilson wanted peace as fervently as the revolutionaries. Because Russell had the same zealous concept of peace, the battle against Germany might have been translated into a more meaningful struggle.

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Phosphorus Fertilized Pasture and Composition of Cow Bone

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A direct relationship between the quality of bone and forage has been long accepted by livestock producers, but with limited actual trials recorded. Fertility of soil and mineral content of pasture forage are generally regarded as requirements of good bone formation and development as well as for overall performance of grazing cattle. Mature cows have approximately 83.6 per cent of the total body phosphorus in their bones (Ellenberger, Newlander and Jones, 1950). These workers found no large differences in percentages of phosphorus and calcium between the various bones of the bovine skeleton. Becker et al. (1957) reported values for breaking strength of cannon bones of dairy cows and related some differences to dietary factors.

The present study was made to determine the effect of phosphorus applied as fertilizer to pasture on the breaking strength, density and concentration of several elements in bone of grazing cows.

Experimental

The fertilizer treatments were on a 42.5 hectare site of Immokalee fine sand at the Range Cattle Experiment Station, Ona, in central Florida, which had been cleared of native vegetation and planted to pangolagrass, *Digitaria decumens* Stent, during 1947-49. Seven different pasture treatments were established: No phosphate (Control), Superphosphate-no lime (Super-no lime), Superphosphate+lime (Super+lime); Concentrated superphosphate (Conc), Rock phosphate (Rock), Colloidal phosphate (Colloidal), and Basic slag. Each treatment involved 6.07 hectares consisting of two non-adjacent 3.04 hectare areas which were in turn divided equally in 1949 to permit an improved rotational grazing program.

In Table 1 the phosphorus fertilizer treatments are outlined. Calcic lime was applied to the Super+lime treatment in 1947, 1950 and 1953 at the rate of 1118 kg per hectare. All areas except the Super-no lime received 2236 kg of dolomitic lime per hectare in 1955 and 1118 kg calcic lime in 1959-60. All treatments had identi-

TABLE 1

Fertilizer applications to pastures, expressed in kg P_2O_5 per hectare

	1947-54		1955-58	
P Source	Kg P_2O_5	Interval	Kg P_2O_5	Interval
Control	none	—	none	—
Super - no lime	56.8	annual	28.4	annual
Super + lime	56.8	annual	28.4	annual
Conc	56.8	annual	28.4	annual
Basic slag	56.8	annual	28.4	annual
Rock	580	every 3rd yr.	none	none after 1953
Colloidal	545	every 3rd yr.	227	in 1957

cal nitrogen, potassium and minor element applications and were presented in detail by Hodges et al. (1964).

No phosphatic fertilizers were applied in any treatment after 1958. During the years 1959 through 1965 the cows were observed for residual effects of the phosphate fertilizer applications. The cows depended entirely on pasture up to 1958, but due to severe weather some low phosphorous feed supplementation in the form of cottonseed hulls and citrus molasses which contained 0.06-0.07 per cent phosphorus as well as urea was necessary during parts of the winter and spring of 1958, 1960 and 1963. Each herd group had free access to common salt and a mineral mixture consisting of 100 parts common salt, 10 parts iron oxide, 2 parts copper sulfate, and 0.1 part cobalt chloride in a two-compartment box. The only phosphorus and calcium provided to the grazing herds was in the forage.

The number of cows on each treatment depended on the amount of pangolagrass forage. Five animals were always on the Control pasture, but 7-10 were kept in the other pastures depending upon forage supply. They generally calved in a 110 day period during January to April and the calves were weaned in September.

Metatarsal or metacarpal bones were obtained from 28 cows when they were removed from the project after approximately 10-18 years of age. Breaking strength was obtained using a Riehle stress machine following the technique of Miller et al. (1962). This procedure involved the static stress weight for breaking bone, distance between supporting edges and cross-section area of bone at breaking point as determined with a planimeter for the calculation

of breaking strength. Density value was determined by weighing a 10-20 gm sample of cortical bone from the breaking point area in air and in water and dividing weight in air by that obtained in water. A bone sample from the breaking area was dried at 100C to dry weight in an oven, and ash determined by heating overnight at 600C (A.O.A.C. 1960). Phosphorus was determined in ash by the phosphomolybdate colorimetric method (Fiske and Subbarow, 1925); calcium, magnesium and iron using the Perkin Elmer Model 303 atomic absorption spectrophotometer technique, and fluorine by the distillation zirconium-alizarin method (Megregian and Maier, 1952; A.O.A.C., 1960).

RESULTS AND DISCUSSION

Values for breaking strength of bones of cows expressed as kg per cm^2 are presented in Fig. 1. The Control group was lowest in

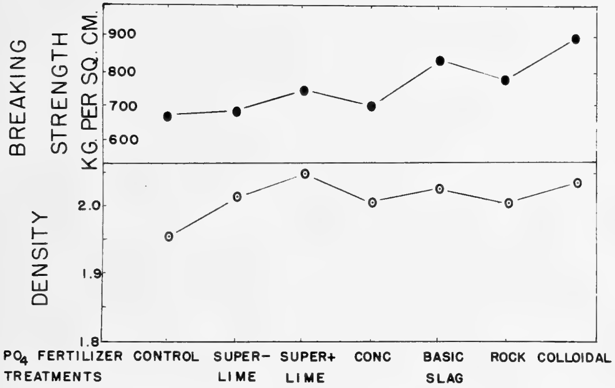

Fig. 1. Phosphorus fertilizer treatments of pasture versus breaking strength and density of cow bones.

breaking strength with an average value of 660 kg per cm^2. Cows grazing phosphate fertilized pastures had slightly greater average values in all six treatments. The Control grmoup averaged a density value of 1.9567 compared to average values of more than 2.0000 for those grazing the phosphorus fertilized pastures. Cows of all treat-

ments had essentially the same quantity of forage per animal but varied in their total phosphorus intake. The Control group grazed grass that had 0.12±0.02 per cent phosphorus on the dry weight basis during 1951-1958 compared to values of approximately 0.2-0.3 per cent phosphorus in those pastures fertilized with various sources of phosphorus. During the seven residual years, 1959-1965, forage from the readily soluble phosphate treatments decreased in phosphorus content to as low as 0.16 per cent.

The average concentration of ash, phosphorus and calcium values in bone of the seven treatment groups are shown in Fig. 2.

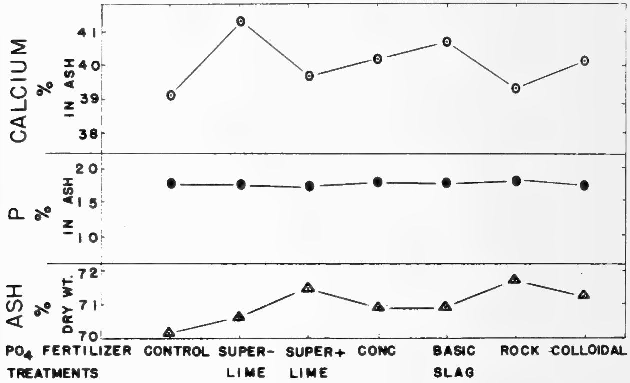

Fig. 2. Phosphorus fertilizer treatments of pasture versus ash, phosphorus, and calcium of cow bones.

The values for ash varied from 70.2-71.8 per cent with no significant difference among treatment groups. Strobino and Farr (1949) reported an average ash content for periosteal and endosteal bovine bone to be 69.7 and 71.4 per cent, respectively.

The average bone phosphorus values were quite constant among the treatment groups and varied only from a low of 17.5±0.3 to a high value of 18.0±1.1 per cent. These data indicate that productive beef cows consuming forage with approximately 0.12 per cent phosphorus can incorporate as much phosphorus in their bone as those grazing forage with 0.2-0.3 per cent phosphorus if the pasture

is not overgrazed. However, the Control cows had significantly less phosphorus in their blood (Shirley et al. 1968).

Calcium values (Fig. 2) in the bone did not vary significantly among the treatment groups. Calcium levels in the blood of these cows were not affected by the fertilizer and lime treatments (Shirley et al. 1968).

As shown in Fig. 3, the Super-no lime treatment group was not

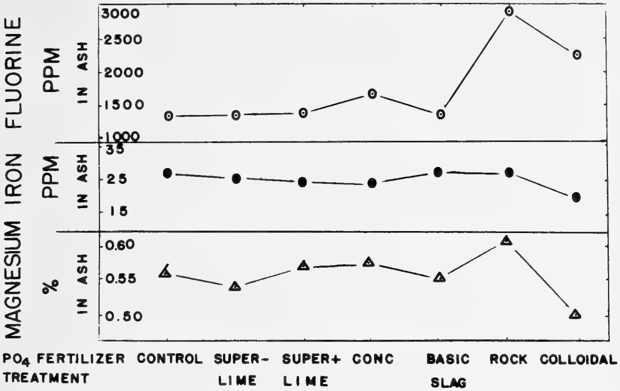

Fig. 3. Phosphatic fertilizer treatments of pastures versus magnesium, iron, and fluorine in cow bones.

significantly different in magnesium content of bone from the other groups although it was the only one that did not receive dolomitic limestone. Average values for all treatment groups were in the range of 0.5-0.6 per cent magnesium in the bone ash. Smith (1959) reported that bone ash in calves decreased from a normal value of approximately 0.75 per cent eventually to one-third of this value when serious clinical symptoms of magnesium deficiency occurred.

The average iron content in bone ash (Fig. 3) varied slightly from 18 to 28 ppm among the treatment groups. Anke (1966) demonstrated that young calves on rations containing 104 ppm iron had a significant decrease in bone iron content over a 140 day period compared to calves fed rations that contained 269 ppm of the element.

Average flourine values are plotted in Fig. 3. Bones of cows

grazing the Rock and Colloidal fertilized pastures were significantly different. Duncan's (1955) test for significance showed that fluorine content of the Rock group was higher than all but the Colloidal group; and that the Colloidal group had more fluorine than the Control, Super-no lime, Super+lime and Basic slag groups. Fluorine occurs at levels of approximately 2-4 per cent in untreated colloidal and raw rock phosphate fertilizer. There was no raw rock phosphate applied after 1953 nor colloidal phosphate after 1957 and the cows were removed from the experiment generally 8-10 years afterwards. Hobbs and Merriman (1962) reported that the fluorine content of metacarpal, metatarsal and other bones of cattle was related to the level of flourine ingested, source of fluorine and length of experimental period. Ammerman et al. (1964) found that steers in the feedlot during 91 days readily accumulated fluorine in the metacarpal bones from dietary colloidal phosphate, calcium fluoride and sodium fluoride. There was some indication of increased breaking strength and density in the present study with the higher levels of fluorine in the Rock and Colloidal treatment groups.

SUMMARY

A study was made of the effect of phosphorus applied as fertilizer in the form of Super- no lime, Super+lime, Conc, Basic slag, Rock and Colloidal phosphates to pangolagrass pastures on the breaking strength, density, ash, phosphorus, calcium, magnesium, and fluorine of metacarpal and metatarsal bones of cows that grazed the pastures for 7-16 years and were 12-18 years of age.

Cows grazing phosphatic fertilized pasture had slightly greater breaking strength and density of bone. Those that grazed pastures fertilized with rock and colloidal phosphates averaged approximately 2900 and 2300 ppm fluorine, respectively, compared to 1400 ppm fluorine in the other five treatment groups. There were no significant differences in composition of ash, phosphorus, calcium, magnesium, and iron in bone due to fertilizer treatments.

ACKNOWLEDGMENTS

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Physical Endurance of Rats Increased by Rutin

K. M. Brooks and R. C. Robbins

Evidence has accumulated in the literature which indicates that rutin (Nutritional Biochemical Corporation), a constituent of several plant species, might increase the resistance of animals to physical exhaustion. Akamatsu (1931) reported that rutin increased the amplitude of the heart beat and increased the minute volume of both intact and isolated frog hearts. DeEds and Couch (1948) also reported stimulation of frog hearts with rutin and Fukuda (1932) found that rutin increased heart action in rabbits. In addition, Teras (1964) reported that rutin had accelerating effects on the respiratory enzymes, succinic dehydrogenase and cytochrome oxidase. Acceleration of heart action and respiratory enzymes would appear to be key processes in the adjustment of the organism from the resting to the active state. Thus, the objective of this study was to determine whether rutin would increase the resistance of rats to physical exhaustion.

Swim tests have been used in a variety of experiments to evaluate the effects of treatments on physical performance (Tan, Hanson, and Richter, 1954; Werboff, Haggett, and Anderson, 1967) and was chosen for the present study. Thirty-six 100-day-old male rats were used. The rats were housed individually in wire mesh open bottom cages and fed a stock diet (Purina Laboratory Chow) prior to and during the 15 day experimental period. The experiment consisted of three phases: (a) a 5 day preconditioning period during which the rats were allowed feed and water *ad libitum,* (b) a one day period during which the treatments were administered and the swim trials conducted, and (c) a 9 day period during which the rats were observed for after effects.

Rutin is only slightly soluble in water and body fluids and easiest to administer to animals in the feed however, under these conditions it is difficult to control dosage. A stomach tube appears appropriate but there is some controversy regarding the efficiency of absorption of rutin from the gastrointestinal tract as only traces could be found in the urine compared with appreciable quantities when fed intravenously (Griffith, Krewson, and Naghski, 1955). Subcutaneous application has been found to be effective as rutin

appeared in the urine as rapidly as after intravenous injections (Griffith, Krewson, and Naghski, 1955). In a search for a solvent for topical application, rutin was found to be highly soluble in dimethyl sulfoxide (DMSO), which has been found to be effective for administering drugs that are relatively insoluble in water (Jacob, Bischel, and Herschler, 1964; Rosenkrantz, et al., 1963). Based on this evidence rutin was dissolved in DMSO and applied topically.

After the 5 day preconditioning period the rats were weighed in order to compute rutin dosage and an area approximately 5 cm in diameter on the back was shaved to permit topical application of the treatments, which were as follows: (a) normal control, (b) DMSO control, (c) DMSO+rutin. Dosage level for the DMSO+rutin treatment was 75 mg rutin per kg of body weight. In order to give the DMSO alone at a comparable level with the DMSO used as a solvent in the rutin treatments, the dosage level was 91 per cent of the DMSO+rutin level. The rats were assigned at random to the above treatments. Six animals were used in the DMSO+rutin and normal control groups. Twelve rats were used in the DMSO group. Here in accordance with Dunnett's (Steel and Torrie, 1960) recommendations, 12 rats were used since this latter group represented a reference standard for evaluation of the two treatment groups. The treatments were applied twice during the day preceding the swim test, 15 hrs before and one hr prior to the swim test. This procedure was based on excretion data (Scarborough and Bacharach, 1949). The swim tests were carried out in a 55 gallon metal drum filled with water to a level 12 inches from the top. Water temperature was maintained at 18 ± 0.5 C by addition of ice. The ice was allowed to melt before the swim test. A weight handicap was provided by a lead collar 1 mm thick by 6 mm wide with the length adjusted to provide a weight equal to 4 per cent of the body weight. Swim time was measured with a stop watch. Testing ended when an animal remained submerged for 30 seconds. The rat was then removed from the water and returned to its cage for post-test observations. Body weight was followed for nine days to obtain a measure of after effects of the DMSO and DMSO+rutin treatments. Food and water were allowed *ad libitum* during this period. Statistical analysis of the data were carried out using Dunnett's test.

The results of the swim tests of the rats subjected to the DMSO

TABLE 1

Swim times and body weight for rats treated with DMSO alone or with DMSO + rutin

Treatment	No	Body wt (gms)		Swim time (min)		Post test wt change (gms*)
		Mean	SD	Mean	SD	Mean
Control	6	377	31	9.70	2.97	+2.3
DMSO	12	386	33	9.39	3.25	+3.9
DMSO + Rutin	6	394	23	12.67†	2.59	+5.3

*Net change during 9 days following swim test; no statistically significant difference
†Statistically significant difference at the $P<0.5$ level

and DMSO+rutin treatments are shown in Table 1. The mean swim time of the rutin treated rats was significantly longer ($P<0.05$) than that of the DMSO treated or normal controls. Body weights before and nine days after the test were not significantly different.

The results of the study confirms the evidence in the literature indicating that rutin might enhance physical performance. The 31 per cent increase in swim time of the rats administered rutin may indicate some usefulness for rutin in situations requiring a high level of energy output, especially since rutin has been reported to show an apparent lack of toxicity in the mammalian body (Griffith, Krewson, and Naghski, 1955).

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Echolocation-Type Signals by Two Dolphins, Genus *Sotalia*

David K. Caldwell and Melba C. Caldwell

The ability to echolocate may be universal among the small toothed whales (Norris, 1968, 1969) although it has been demonstrated experimentally for but two species: the Atlantic bottlenosed dolphin, *Tursiops truncatus* (see Norris et al., 1961) and the harbor porpoise, *Phocoena phocoena* (see Busnel, Dziedzic and Anderson, 1965; Busnel and Dziedzic, 1967). Sound emissions that appear to be echolocation-type signals have been recorded in many species of odontocete cetaceans, however (Norris, 1969).

The small freshwater Amazon river dolphin, *Sotalia fluviatilis*, has been maintained but rarely in captivity. An inhabitant of the Amazon river and its tributaries, its capture and transport are difficult and expensive. Additionally, it goes into fatal "shock" very frequently when handled. It is not surprising, therefore, that there are no published records of its sound emissions (see Schevill, 1964; Tavolga, 1965, 1968; Evans, 1967; Poulter, 1968, the species listed as *Sousa pallida*). Consequently, presentation of our rather limited data seems indicated as much time could elapse before more and better experimental evidence becomes available.

On 12 November 1968, Marineland of Florida obtained two of this species, a mature female (Fig. 1), about 140 cm in length

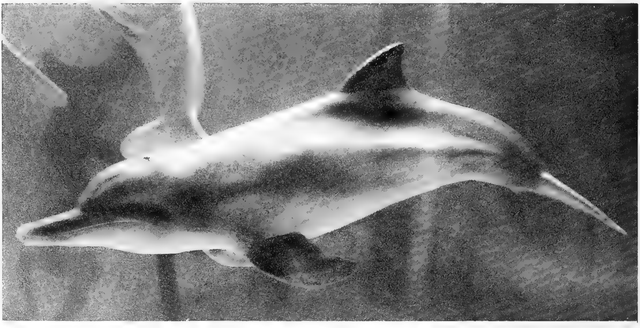


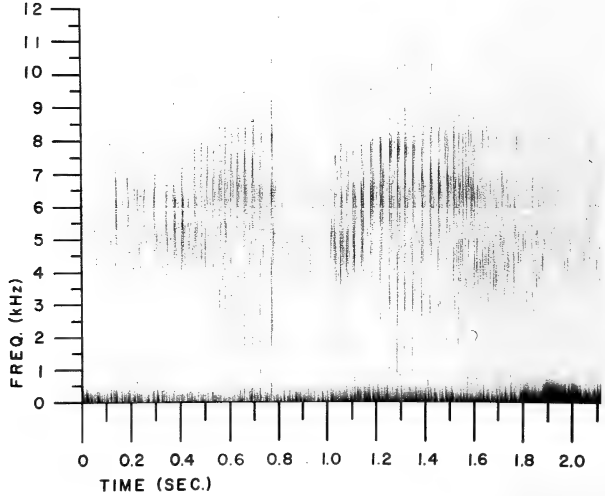
Fig. 1. Live adult female *Sotalia fluviatilis* (MLF 255) captive at Marineland of Florida in 1968.

from tip of upper jaw to fluke notch, and her immature male offspring that measured 106 cm. The animals had been captured on 4 November in the Napa river about 15 miles from Iquitos, Peru. They were held in captivity in Iquitos and then flown directly to Miami. After a layover there for a few hours, they were trucked directly to Marineland. Both were eating fish shortly after capture, although the juvenile also continued to nurse frequently.

The animals were held for the first two days at Marineland in a small holding pen. During this time we recorded them for several hours, when we were introducing no outside stimuli other than the hydrophone, and during feeding episodes. Echolocation-type click trains were emitted by both animals during feeding (Figs. 2 and 3). The onset of the sounds correlated directly with the approach of the animals to the fish and ceased when the fish was grasped. Louder click trains were recorded several times when the juvenile approached the hydrophone, while facing toward and appearing to inspect it (Fig. 4).

The loudness of these click trains directed toward the hydrophone as opposed to the softness of the clicks recorded when the animals were searching for or investigating a fish may have been a function of the directionality of the emitted sound. Directionality of emission plays a large part in the degree of loudness of clicks picked up by a hydrophone (Schevill and Watkins, 1966; Norris, 1968, 1969), but this is more characteristic of the higher frequency ranges (up to 208 kHz) than of the lower frequency ranges at which we were recording (up to 20 kHz). The clicks made at lower frequencies retain an important fraction of their energy up to 20-25° bilateral to the midline in one species, the rough-toothed dolphin, *Steno bredanensis* (see Norris and Evans, 1967).

The clicks of the mature female (Fig. 2) are extremely broad band, many with energy above the upper limits of our equipment (20 kHz). A dominant frequency, demonstrated more clearly at one-half the recorded tape speed (Fig. 2*b*), appears to be present in the individual clicks between eight and 15 kHz. The clicks emitted by the small male when approaching a fish appear on the sonagram to have limited energy above one kHz (Fig. 3), but we did not note the position of the animal's head. A sonagram of the clicks emitted by this same animal when approaching and facing the hydrophone indicates that at least these particular clicks have a


FREQ. (kHz)
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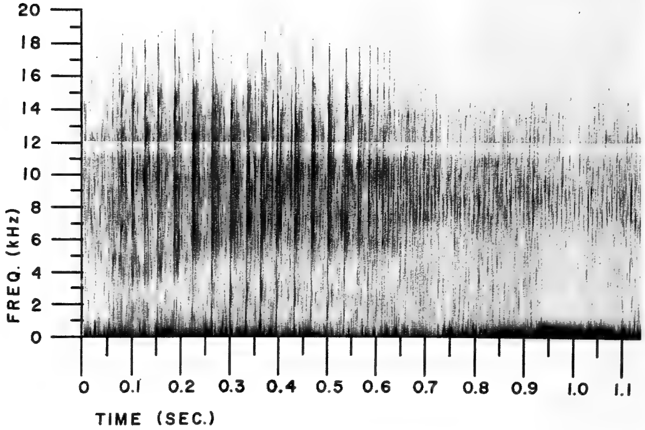
TIME (SEC.)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TIME (SEC.)

Fig. 2. Phonations of *Sotalia fluviatilis.* Echolocation-type signals emitted in daylight by an adult female (MLF 255) as she approached a sinking dead food fish at Marineland of Florida, November 12, 1968. Upper figure (*a*): Effective filter bandwidth 300 Hz. Lower figure (*b*): Section of (*a*) from about 1.0 to 2.0 seconds played at half speed. Note increasing click repetition rate as the dolphin approached the fish. Effective filter bandwidth 600 Hz. Horizontal line at 6 kHz in (*a*) and 12 kHz in (*b*) is an artifact.

much broader sound spectrum. Dominant frequencies in the broad band click emissions of sperm whales (*Physeter catodon*) have been shown and discussed by Backus and Schevill (1966). These authors tentatively placed the dominant frequency into the category of an individual rather than a species characteristic.

Shift in frequency is apparent in the echolocation clicks of at least one species: the Atlantic bottlenosed dolphin (Norris, 1969). There is also a suggestion of a slight upward shift in the dominant frequency of the clicks in the *Sotalia* click train shown in Fig. 2*b*.

No pure tone or complex periodic wave sound emissions (either usually termed a "whistle") were recorded during the above period. Two days later the animals were placed in a large community tank with four Amazon dolphins, *Inia geoffrensis.* The second day following their introduction, the small male *Sotalia* was attacked sexually by a large adult male *Inia.* The *Sotalia,* unable to escape, was forced many times to the bottom of the tank where the larger male

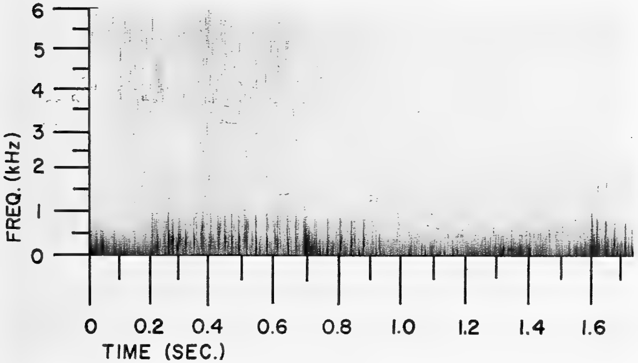

Fig. 3. Phonations of *Sotalia fluviatilis.* Echolocation-type signals emitted in daylight by a juvenile male (MLF 256) as he approached a sinking dead food fish at Marineland of Florida, November 12, 1968. Effective filter bandwidth 300 Hz.

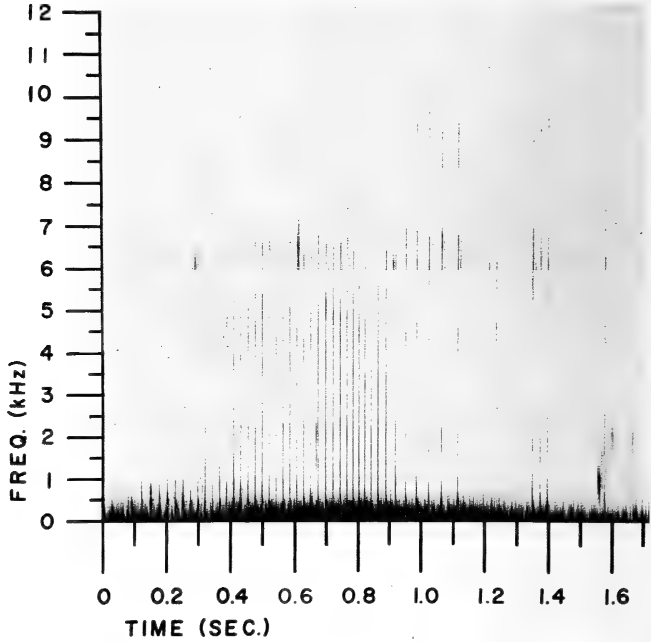

Fig. 4. Phonations of *Sotalia fluviatilis*. Echolocation-type signals emitted in daylight by a juvenile male (MLF 256) as he approached the hydrophone at Marineland of Florida, November 12, 1968. Energy from 0 to 2 kHz at about 1.6 seconds is from a known non-dolphin source. Effective filter bandwidth 300 Hz. Horizontal line at 6 kHz is an artifact.

effected several intromissions, most probably into the genital slit of the smaller animal. This occurred at night when it required about an hour to find help to separate the immature animal from the large harassing male. Placed in a separate holding pen, the immature animal was quivering, unable to retain his balance, and died in about 45 minutes. No whistles were heard from the tank during the entire episode. Underwater recordings of the episode were not made but as the animal was being supported and stroked by attendants for the 45-minute interval prior to death, they would most probably have heard any whistle emissions. The mother

showed no evidence of distress and made no audible vocalizations. Nor did she whistle on any of the occasions that she was recorded when netted or removed from the tank for medication (on ten occasions).

The mother died on 19 December 1968, and our period of observation and recording of this species therefore covers 40 days.

Spotte (1967) reported hearing loud high-pitched whistles from a male *Sotalia fluviatilis* held with two *Inia* at the Niagara Falls Aquarium, but did not record them. Under the above conditions, an adult female and juvenile offspring bottlenosed dolphin almost certainly would have whistled. Although the absence of whistles noted above should be on record, it does not necessarily follow that we can infer that S. *fluviatilis* lacks the capacity to whistle, as there are great individual and specific differences in the number of whistles emitted by those Cetacea that are capable of producing this type of sound.

SOUND EQUIPMENT

All of the recordings discussed in this paper were made at a tape speed of 7.5 inches (19 cm) per second with a Uher 4000 Report-S recorder, which at that tape speed had a flat frequency response of 40 to 20,000 Hz per second. An Atlantic Research Corporation model LC-57 hydrophone was used, with a special preamplifier designed and built for the system by William E. Sutherland of the Lockheed-California Company. Sound spectrograms (sonagrams) were prepared on a Kay Sona-Graph model 662A Sound Spectrograph Analyzer calibrated in two sections from 85 to 12,000 Hz per second. When the recorded tape speed is reduced by half, and then fed into the analyzer, the response of the latter is doubled to 24,000 Hz per second. The effective filter bandwidths for the illustrated analyses are indicated in the figure captions.

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Studios, Inc. The photographs are by William A. Huck of Marineland of Florida. Assistance in making the recordings was provided by James Francis Miller III.

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The Paleospecies of Woodpeckers

Pierce Brodkorb

The fossil history of the woodpeckers, comprising the family Picidae, has been alleged to extend back into the early Tertiary. The reports of supposed woodpeckers covering the span from the Eocene through the Miocene epochs were published during the infancy of paleornithology nearly a century ago, and it now appears that all such records should be referred to other families in the order Piciformes or even to entirely different orders.

Alleged Early Tertiary Woodpeckers

From Aquitanian deposits in France, Milne-Edwards (1871) described two supposed woodpeckers, *Picus archiaci* and *Picus consobrinus*. Lambrecht (1933) not only retained them in the Picidae but even erected the genus *Palaeopicus* for them. Ballman (1969) demonstrated that they are not woodpeckers but belong in the order Coliiformes, presently confined to Africa.

Marsh (1872) described *Uintornis lucaris* from the middle Eocene of Wyoming and stated that it was probably related to the woodpeckers. He did not illustrate his type, but Shufeldt (1915) published a life-sized photograph of the tiny specimen and stated that it was in no way related to the woodpeckers. On the basis of Shufeldt's photograph I recently attempted to place *Uintornis* in the Bucconidae (Brodkorb, 1970), but Joel Cracraft has now sent me enlarged photographs of the type, which show that it is referable to the Cuculidae.

Depéret (1887) described *Picus gaudryi*, still another supposed woodpecker, from the Tortonian Miocene of France. The name was based on a femur and a tentatively referred distal part of a tibiotarsus, the latter without any description. Nothing in the brief characterization of the femur is diagnostic of the Picidae. The head of the femur is too flat proximally, and its neck lacks the constriction present in the Picidae. The drawing also fails to show the prominently raised area of attachment of the iliacus muscle external to the anterior intermuscular line, characteristic of the woodpeckers. The distal end is depicted as being strongly inflected, whereas in

woodpeckers the femur is straight, with the condyles expanding to both sides. If the drawing is accurate, the type cannot represent a woodpecker.

PLIOCENE AND PLEISTOCENE WOODPECKERS

Valid paleospecies of woodpeckers are known only from the Pliocene and Pleistocene epochs of North America. They include *Pliopicus brodkorbi* Feduccia and Wilson (1967) and *Palaeonerpes shorti* Cracraft and Morony (1969) from the Lower Pliocene of Kansas and Nebraska, respectively, and *Bathoceleus hypalus* Brodkorb (1959) from the Upper Pleistocene of the Bahamas. Additionally, 28 neospecies of woodpeckers are recorded from Pleistocene deposits in the Holarctic and Neotropical regions.

A BLANCAN IVORY-BILLED WOODPECKER

In western Texas Dr. Walter W. Dalquest recently discovered a rich vertebrate fossil locality, in which the most abundant large mammal is a three-toed horse, *Nannippus phlegon* (Hay). Remains of birds are common in this deposit and include a specimen of a large woodpecker. Related to the Guatemalan ivory-billed woodpecker, it represents a Neotropical element in the fauna. This fifth paleospecies of woodpecker is described below.

Campephilus dalquesti, new species

Holotype. Distal half of left tarsometatarsus (Fig. 1) collected in 1969 by Walter W. Dalquest, Midwestern University, in the Upper Pliocene (early Blancan) "black quarry", on Beck Ranch, just south of U.S. Highway 180 and about 10 miles east of Snyder, Scurry County, Texas.

Generic Diagnosis. Tarsometatarsus large, as in *Campephilus* Gray and *Dryocopus* Koch (smaller in other genera of Picidae). Agrees with *Campephilus* in having (1) shaft wide and stout, with only slight compression near middle (in *Dryocopus* shaft narrower, much compressed near middle, and flaring distally); (2) area of attachment for metatarsal I wide, indicating a large hallux (articular area smaller in *Dryocopus*, which has a relatively small inner

Fig. 1. *Campephilus dalquesti*, n.sp. Holotype tarsometatarsus, Midwestern University, from Scurry County, Texas. Length as preserved, 34.8 mm.

hind toe); (3) area proximal to middle trochlea with a deep fossa for reception of talon of basal phalarx of outer front toe (fossa shallow in *Dryocopus*).

Specific Diagnosis. Tarsometatarsus with shaft slightly compressed subterminally (as in recent *C. principalis* (Linnaeus) of southeastern United States wide throughout in recent *C. guatemalensis* (Hartlaub) of Middle America and recent *C. rubricollis* (Boddaert) of South America. External distal foramen small but in normal position low on shaft (as in *C. guatemalensis*; small but elevated on shaft in *C. rubricollis*; large and low in *C. principalis*). Internal distal foramen minute and much lower than external foramen (minute and slightly higher than external foramen in *C. guate-*

malensis; minutely open only on plantar surface and lower than external foramen in *C. rubricollis*; larger than external foramen and slightly lower in *C. principalis*). Facet for metatarsal I wide and deep (indistinct in *C. guatemalensis*, *rubricollis*, and *principalis*). Base of inner trochlea flaring smoothly from shaft (as in *C. principalis* and *rubricollis*; edge of trochlea with a marked protuberance in *C. guatemalensis*). Middle trochlea wide, 74 per cent of least width of shaft (70 per cent in *C. principalis*, 67 per cent in *C. rubricollis*, 56 per cent in *C. guatemalensis*). Rotular groove of middle trochlea wide and shallow with its inner rim slightly overhanging side of trochlea (as in *C. principalis*; groove wide and deep with inner rim strongly overhanging side of trochlea in *C. rubricollis*; groove narrow and deep with inner rim strongly overhanging side of trochlea in *C. guatemalensis*). Outer trochlea with a deep depression at base of its outer face (as in *C. principalis* and *guatemalensis*; depression shallow in *C. rubricollis*). Accessory trochlea turned back somewhat less than 90 degrees from anterior plane of shaft (turned about 90 degrees in *C. principalis*; more than 90 degrees in *C. guatemalensis* and *rubricollis*).

Measurements. Size similar to that of *C. guatemalensis* and *rubricollis* (much greater in *C. principalis*). Length of preserved portion of tarsometatarsus, 24.7 mm (length of entire bone 34.8 in *C. rubricollis*, 36.1 in *C. guatemalensis*, 47.4 in *C. principalis*; 27.4-31.9 in 3 Recent *Dryocopus lineatus* (Linnaeus) from Mexico and Surinam; 35.4-36.8 in 3 Recent *D pileatus* (Linnaeus) from Florida; 37.1 in 1 Recent *D. martius* (Linnaeus) from Russia). Least width of shaft, 3.1 (3.0 in *C. rubricollis*, 3.4 in *C. guatemalensis*, 4.0 in *C. principalis*; 2.1-2.5 in *D. lineatus*, 2.5 in *D. pileatus*, 2.5 in *D. martius*). Width of middle trochlea, 2.3 (2.0 in *C. rubricollis*, 1.9 in *C. guatemalensis*, 2.8 in *C. principalis*; 1.8-2.1 in *D. lineatus*, 2.0-2.1 in *D. pileatus*, 2.0 in *D. martius*). Depth through accessory trochlea, 5.5 (5.0 in *C. rubricollis*, 5.6 in *C. guatemalensis*, 6.5 in *C. principalis*; 4.3-4.75 in *D. lineatus*, 4.9-5.2 in *D. pileatus*, 4.7 in *D. martius*). Least depth of shaft, 2.7 (2.7 in *C. rubricollis*, 2.5 in *C. guatemalensis*, 2.9 in *C. principalis*; 1.8-2.05 in *D. lineatus*, 2.1-2.5 in *D. pileatus*, 2.1 in *D. martius*).

Acknowledgments. I am happy to dedicate this new species to Dr. Walter W. Dalquest in recognition of his extensive work on the vertebrate paleontology of Texas, and for allowing me to study the

birds of this and other localities. I am also indebted to Dr. Richard Zusi for the loan of the specimen of *C. principalis* from the Fuert village site in Ohio (see Wetmore, 1943).

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Military March Lands, a History and a Horoscope

Duane Koenig

March is defined by the dictionary as "a boundary or border; especially a border or a tract of land along a border, of a country" (Emery and Brewster, 1936). It is likely to be an area far from the center of political, economic, and social power in its state. Cyril Falls, the British military historian, declared in a preface, "Every historian to some extent uses his acquired knowledge without references. . . . Here the references are used mostly to support the more striking statements or for direct quotations" (Falls, 1962). That is the case below. The cause of history, it is said, may be advanced "either by adding new facts or making new interpretation of the relations between facts" (Holt, 1963). The lecturing to assorted history classes for thirty years suggests generalizations and patterns for human activity that lend themselves to support of a hypothesis. It is that military march lands, familiar since antiquity, declined in the nineteenth century, revived in the twentieth, and now thanks to technology, may vanish entirely.

Charles Dickens observed in 1842, after he visited the halls of the American Congress, that the question put to him about the orators he had just heard, was not, "What did he say?" but "How long did he speak?" (Dickens, 1903). To the suitability of that query may be added the admonition of Giambattista Vico, "A man is properly only mind, body, and speech, and speech stands, as it were, midway between mind and body" (Bergin and Fisch, 1961). In good hope, speech reduced to writing should neither disturb by its vacuity nor tax by its length. A historical survey of military march lands can possibly meet the former criterion, and short prognostication for the future, the latter.

Woodrow Wilson on November 11, 1918, appealed for "the establishment of just democracy throughout the world" (Allen, 1959). One can admit that as a form of government, democracy has lost ground since that time. A by-product to its recession is rarely mentioned: the resurrection of military marches and fortified zones along many lengths of the globe's tens of thousands of miles of international boundaries. In a world composed of democratic (equate with peace-loving) states, presumably military marches would be unfortified with a handful of customs and police agents servicing the international traveler. Such a world would be a logical outgrowth of the European state system which gained maturity in the late nineteenth century.

Victorian politicians and voters, had they thought about the matter at all, could have observed a drift towards the abolition of garrisoned frontiers. A cynic might label this with novelist F. Marion Crawford, "the nasty atmosphere of progress with a capital *P*" (Pilkington, Jr., 1964). Some of the reasons for the drift rested in military strategy. Francis Bacon said, "Histories make men wise" (Bartlett, 121). Accordingly, they should be consulted. From the days of Louis XIV to the invention of the Maxim gun, defense was frequently at a disadvantage compared with offense. The classical principle of strategy was gaining control of a people through destruction of the enemy's armies on which depended his power to resist (Peltier and Pearcy, 1966). In negotiation the object was the enemy's provinces which gave power, wealth, face (Hill, 1945).

Tactics, used first by professional and later by conscript armies, to gain economy of force asked for concentration not along frontiers but at strategic internal points. A web without a spider was worthless (Churchill, 1949). Generals debated the maximum possible line of enemy penetration before counterattacking. An illustration may be found in the opening campaign of the Kaiser on the Russian Front in 1914. Prudence recommended a German retirement from East Prussia to the Vistula River pending victory over France. Fear of political repercussions led to evacuation of national territory (home of the Junker officer class, many of whose members were fighting in the West) and demands of Field-Marshal Conrad von Hötzendorf for an assault in Russian Poland, prevented this withdrawal.

Other explanations can be advanced for demilitarization of frontiers. Europe was spared a general war between 1815 and 1914. British-style shopkeeper diplomacy won successes against Prussian-style prestige diplomacy. Canal and railroad building, movements for written constitutions and free trade, all encouraged open borders and unrestricted transit. From England to Russia and Turkey it was possible to travel before 1914 without hindrance. A passport was little more than a souvenir, a letter of introduction. Albeit Europe was an armed camp, troops were barracked at major cities and railheads. They were more likely to be invoked to hold their own kind in check than to hasten goods wagons to a threatened boundary. These same conditions usually prevailed overseas.

While political frontiers delineated on the spot may be pronounced innovations of the national state and the modern period, strategists who think in terms of military marches know these are almost old as history. Two hundred years before Christ the Chinese monarch Shih Huang Ti, not exactly a green-ear, used convict labor to piece together existing fortifications into a Great Wall. It was continued by his successors until it stretched seventeen hundred miles. This insured China's northern flank. Imperial Romans understood that they could not extend indefinitely in every direction. Though the Chinese and Romans did not have the modern concept of a state with fixed limits, they knew that beyond their lands were Barbarians, rude peoples who could be counted on periodically to create disturbances. An open frontier was an open invitation to these outlanders who thought *à la guerre comme à la guerre*.

When limits were set up for the Roman Empire, fortifications were improvised and advantage taken of natural lines of defense such as the Rhine-Danube Rivers. Hadrian in the second century completed a wall from Solway Firth to the North Sea to preserve Roman Britain against Scotland. Necessity urged a stout defense in the East, where the Parthians and Persians were capable of assault at any moment. Rome maintained a vigilant border guard along these fronts. As in many march lands, this guard took the form of resident militiamen, that is, soldiers planting crops and living with their families. Came hostilities, and the militia abandoned their farms on short notice and occupied local strong points.

To back up these frontiersmen were armies of strategic reserve. The reserves were at first foot soldiers with a few horsemen, later

archers on horses in the Persian fashion. They were instantly ready to move over the superb Roman roads to support the militia anywhere. The border guard was made up of provincials, Barbarian mercenaries, or allied tribes. The several reserve armies of Diocletian's reign, 284-305 A.D., were habitually recruited from among Barbarians (Boak, 1929). Justinian, reigning over the Eastern Roman Empire in the sixth century, built a noteworthy series of fortresses along the lower Danube and in North Africa, structures with walls several feet thick and tall as two story houses. He added the innovations that the general commanding the reserve would take charge of the beleagured forces, and that militiamen would have precedence over civilian officials.

The rough and tumble medieval period employed like arrangements. Charlemagne created no less than half a dozen marches on the limits of his realm. These served for defense and were centers of Germanization and colonization. The Spanish March in Catalonia and the Austrian March in Central Europe were the two most celebrated. One needs but tour Austria to recall the military origin of the land. Castles are perched on mountain peaks. On the lower slopes tilled fields extend in all directions away from them. Norman England planted marcher lords next to Wales and Scotland. These men built castles and acted as captains for their zones. The Kingdom of Jerusalem was Christendom's most eastern march during the Crusades. One Crusading order, the Teutonic Knights, functioned after the holy wars, settling East Prussia and the Baltic area. Another, the Knights Hospitalers, garrisoned Rhodes initially and then Malta. Because of its early role, one of the former Papal States was called the Marches. Incidentally, *march, mark, margrave, marchese, marquis,* and *marquess,* are derived from a common linguistic source.

With rise of the modern territorial state, history furnishes many more cases of guarded frontiers, artificial or natural (Prescott, 1965). The political-geographical terms Military Croatia and Serbian Military Frontier are reminders of the alert the Hapsburgs kept for generations against the Ottoman Turks. For a different front, reminder of a sometime march, compare "The Watch on the Rhine." The treaty of Ryswick, 1697, granted the Dutch the privilege of garrisoning against Louis XIV certain Barrier Fortresses in the Spanish Netherlands. As late as the spring of 1792, preparing for

the publication of his *Travels in France and Italy*, the English agriculturist Arthur Young spoke of France's splendid system of fortresses, north and east of Paris (Young, 1934). And Napoleon erected the Grand Duchy of Berg as march against Prussia.

The reunion of Belgium and Holland after the fall of Bonaparte was arranged in part to deter possible French aggression. Britain promised the House of Orange £2,000,000 to fortify Belgium. Decay of march lands began thereafter. Post Congress of Vienna, 1814-1815, Austria might maintain the Quadrilateral Forts in the middle of Lombardy-Venetia, and France could reinforce Belfort, Metz or Toul. However, these fortresses were not squarely on boundaries. Victorians in the age of bad taste (*mauvais goût*, which was really not so *mauvais*) neglected marches. Their day appeared over.

This was not to be so. During the last 40 years nations have turned back to the ancient military marches for security. Open frontiers are associated with disarmament; disarmament is linked with security. There was no security during the Great Peace which followed the Great War. France was first to awaken to this. That country had never seriously considered the League of Nations capable of providing adequate defense. With America and Britain refusing blank check aid after the 1918 Armistice, the Third Republic resorted to other measures. Abortive intrigues were initiated to acquire the Saar territory and to set up a Rhenish Republic as buffers against Germany. Hard military alliances were negotiated with Poland and the Little Entente. Finally construction of the Maginot Line and the Mareth Line (in Tunisia) was begun. The Nazis replied by putting up the West Wall or Siegfried Line opposite the Maginot. France subscribed to the Locarno Pacts of 1925 which proclaimed the existing German-Belgian-French boundaries and signed the 1928 Pact of Paris outlawing war. Little confidence was placed in such instruments. Under the circumstance the Geneva Disarmament Conference of 1932-1934 had thin success.

Another complication intervened, the successful consolidation of its regime by the Soviet Union. Since establishment in 1917 this government had excited the most lively doubts about its willingness to respect international frontiers. When military march lands became common after Hitler's War, many, though not all, arose in corners of the world where Communist and Western interests met

in juxtaposition. The lapse into Bolshevism of the Iron Curtain countries and China pushed the process forward. Thinking in the West was that Good Neighbor relations often were impossible with many of the Warsaw Pact states, Soviet China, North Korea, North Viet Nam, or Red Cuba. Hence there must be containment, and, if needs be, marches to withstand aggression, modern marches with all the panoply of radarscopes, jet bombers, and nuclear missiles backed up at sea by aircraft carriers and Polaris submarines. Most people can remember the militarization of the South Florida march during the 1962 Cuban missile confrontation with the Russians.

Germany, Berlin, Palestine, Kashmir, Korea, Cyprus, and Viet Nam, at one time or another, in the quarter-century after V-J Day were partitioned, generally along former cease-fire lines. American armed strength underwrote South Korea, Japan, Okinawa, Siam, Philippines, Formosa, and South Viet Nam. Greece was spared a bleeding frontier with her northern Communist neighbors largely because of the defection of Jugoslavia and Albania from Kremlin control. A military march existed between Yemen and Aden before the British abandoned the second, 1967, and still between Mesopotamia and Persia. Communist Hungary policed her frontier against neutral Austria. A march exists at present writing between Algeria and Morocco, and Castro's Cuba is heavily watched by the United States. The MacMahon Line is garrisoned by India and China, and shooting incidents have occurred along its course. Truce lines separate India and Pakistan in Kashmir. Malaysia and Indonesia met in occasional battle in Borneo until mid-1966. In 1969 Chinese and Soviet forces clashed on the Ussuri River, dividing line between Manchuria and Siberia's Maritime Provinces and perhaps at points along the borders of Siberia and Sinkiang. If world trouble spots are listed, they generally turn out to be marches (Jackson, 1962).

Russian proposals for evacuation of all foreign troops from the North Atlantic Treaty Organization and Warsaw bloc, states coupled with limited air inspection rights over nuclear and missile bases, demonstrated that NATO countries and the Warsaw powers were patently rival marches. The Paris peace talks which started in 1968, treated of South Viet Nam, America's march in Southeast Asia. The August 21, 1968 occupation of Czechoslovakia by the Soviets further emphasized the point. What rehabilitation of the

military march means is that much of the world found itself abandoning the aspiration of all states dwelling peacefully side by side. Frontiers had to be enforced. The moral strength of world opinion, represented by the United Nations and the neutralist group of emerging countries, was not enough to stay any major aggressor.

Military geographers and political scientists might well look into two problems. What impact, if any, on the foreign and the domestic policy of a state do quasi-permanent military marches have? Does the history of those lands which feel need to militarize precise boundaries teach any lessons which may be valuable today? Though Winston S. Churchill in *Their Finest Hour* opined, "Past experience carries with its advantages the drawback that things never happen the same way again," in case of marcher territories, history does seem to have gone around the full circle (Churchill, 1949).

What of the future? It is difficult to cast the horoscope. If Wilbur and Orville Wright did not in the long run ruin irretrievably the value of marches by overflight, 1957's Sputnik and 1970's space machines may well do so. Nuclear armed Intercontinental Ballistic Missiles, let alone Multiple Independently Targetable Reentry Vehicles, biological warfare, Polaris underwater craft, and National Liberation Fronts may reverse the spread of military limits. They easily overpass boundaries. Hopefully, prosperity engendered by the European Common Market, the Outer Seven, and other trading programs may serve to eliminate economic barriers even as the old Zollverein of a century and more ago paved way for Bismarck's German unity. Consolation may be found in the folk proverb, "The soup is never eaten as hot as it is cooked."

It may be hazarded that civilization is on the verge of an era that will end the march. People argue that the trophies of war are changing, that the world is ruled by physical energy. Here is that view. Men in the past when not fighting for honor, adventure, prestige, or religion, sought sources of energy that could be turned into wealth, provinces with slaves, water, wind, wood, and coal. Subsurface minerals besides gold and silver were recognized as valuable even before the 1700's. Sufficient energy was always lacking.

Since inequalities existed among countries, arable land, cities,

factories, and mines could add to the totals of the "have not" nations. England recognized the back of the coin twenty decades ago. Raw materials from underdeveloped areas and consumption by colonial markets kept its shop wheels turning. Strategic trade narrows like Gibraltar, Suez, and Malacca, with the Panama Canal built by the friendly United States, controlled the routes by sea to and from these markets. Naval enthusiasts taught that the sea regularly defeated the land, the whale beat the elephant. To preserve her monopoly, Great Britain relied on the Royal Navy. It would have been even better had it had wheels.

Today three particular types of energy are coming of age and present different prizes of war: automation, scientific agriculture, and nuclear power. These hold a potential for wiping out poverty and balancing unequal natural resources. These can move men to a new stage of history and extinguish former ideas of hours of labor, supply and demand, level of trade. A great treasure is human intelligence. One nuclear physicist or mathematician, it is alleged, is worth a province unless that province contains rare earths good for firing atomic reactors.

The world's reserves of energy in form of fossil fuels, i.e., coal and oil, equal 3-1/2 million million tons of coal. In uranium and thorium the globe has ten to twenty times the known storehouse of fossil fuels. These can be wasted should there be a war fought with atomic weapons. A poetaster in the 1969 *Farmer's Almanac* published this tercet:

> I shot an H-bomb in the air;
> It fell to earth, I can't say where;
> The place it fell's no longer there.
>
> (Pease, 1969)

The current peacetime rate of consumption, not counting population rises, shows the fossil fuels will last eight hundred years. With available radio-active minerals, atomic power stations can take care of any of the world's energy needs into the far distant future. Fair exchange among states of these sources of power may even make military conflict, per those who emphasize economic causations for war, and by consequence, march lands, out of date.

Save for guerrilla areas such as Viet Nam, planes and missiles and space satellites can sound the knell of march lands. New energy forms can by proper assignment make international struggles

antediluvian. Military march lands may become as extinct as *Brontosaurus rex.*

The talkative Dr. Samuel Johnson loved travelling in a carriage because the company could not leave him. Unfortunately, the essayist has no captive audience for the reader can simply close the book. But Dr. Johnson was wise enough to admit, "the carriage must stop sometime and the people must come home at last" (Halliday, 1968). He had a point.

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Some British Impressions of Theodore Roosevelt

George C. Osborn

After months of failing health, Theodore Roosevelt died in his sleep on January 6, 1919, at Sagamore Hill, his home in Oyster Bay. British sources of opinion and thought noted the passing of this illustrious American, as did newspapers and journals in the United States. P. W. Wilson, of the London *Daily News,* (January 7, 1919), wrote of a recent visit with this "American National Hero." The Englishman found the American reclining on a couch. He was simply clad in a dressing gown and bedroom slippers. A couple of books lay nearby. "His sunburnt face was pale and there was an invalid whiteness about his strong and shapely hands." For nearly an hour they chatted, "not in anecdote as was Roosevelt's custom but plainly with a view of creating an impression." An impression that he was not a sick man. "He knew precisely what he wanted to say and he said it with a crisp accuracy of phrase," concluded Wilson.

In characterizing Theodore Roosevelt the British press spoke most often of his tireless energy. He was the most "vital and strenuous American character," said the London *Daily Chronicle,* (January 7, 1919). Frank Dilmot, the *Chronicle's* reporter stationed in New York, was impressed by Roosevelt's "vigor and powerful physique [which] gave the impression of tremendous strength and energy," his contagious democratic spirit, his unclouded self-confidence and his fresh enthusiasm. No one could ever think of him otherwise than young. The London *Daily Mail,* (January 7, 1919), felt that Roosevelt's most personal quality was "pure energy rather than pure reason." The London *Daily News* (January 7, 1919) believed the dominant note of Roosevelt's character was a strenuousness which showed itself in earliest childhood and continued throughout his extremely useful life. Indeed, according to the *Daily News,* (ibid.) Roosevelt's mother said of her son, when he could scarcely toddle, "If God were not taking care of Theodore he would not be here now." Sir Robert Borden, Prime Minister of Canada, who was in London at that time, commented on Roosevelt's "impressive personality, his remarkable ability, his restless energy." (London *Westminster Gazette,* January 7,

1919) James D. Whelpley, an English journalist who lived for many years in Washington and who knew President Roosevelt personally, was impressed by his fighting qualities, by his tremendous energy, and by his stalwart support of social justice (ibid.). The London *Observer*, (January 12, 1919) as did many other newspapers, stressed other traits of Roosevelt. In addition to his vitality, his strenuous life, his dedication to hard work, Roosevelt "stood for simplicity both of life and character." The London *Times* (January 7, 1919) told its readers that Roosevelt was "an enthusiast and an idealist," and added that "strong common sense and moderation characterized him." The Manchester *Guardian* (January 7, 1919) summarized Roosevelt's unusual life by saying that "his vitality, his energy, his versatility, the wealth of his exuberance distinguished him among contemporary public men." The London *Daily Telegraph* (January 7, 1919) thought Roosevelt the "complete American," whether in war, politics, and sports, in moral and physical energy. Indeed, he was "energy incarnate." His inspiring strenuous life made him famous all round the world. The London *Review of Reviews* (1919a) noted that Roosevelt's "ideal of a statesman was that of a practical idealist." The thought progress was accomplished by the man who did the things which should be done and not by the man who talked about how they ought to be done.

Several sources of British opinion spoke of the former President's philosophy of work and energy coming from a Scriptural foundation. The Edinbourg *Weekly Scotsman* (January 11, 1919) told its readers that shortly before Roosevelt was suddenly called to the Presidency by President McKinley's assassination, the Vice President, while in church was invited into the pulpit. He read a short portion of Scripture from James, Chapter 1, verse 22: "Be ye doers of the Word, not hearers only." In a brief sermon he expressed his attitude toward religion and public life when he said: "The man who observes all the Commandments of the Church, but who does not carry them in his daily life, is not a true Christian." The London *Daily Telegraph* (January 7, 1919) revealed Roosevelt's affection for the statement in the book of Ecclesiastes, Chapter IX, verse 10: "Whatever thy hand findeth to do, do it with thy might."

Roosevelt's energy, though abundant, was by no means merely physical. Several members of the English press were aware of his

vigor in conversation. The London *Westminster Gazette* (January 7, 1919) declared that Roosevelt's "strength in conversation appeared inexhaustible." He was the "least arrogant and the least immodest of talkers," concluded the *Westminster Gazette*. Sir Robert Borden was equally aware of this trait in Roosevelt, saying that the American had an uncanny "vigor of expression," which was coupled with a "wide vision and a high idealism" (ibid.). The London *Times* (January 7, 1919), spoke of Roosevelt's showmanship as a public speaker and added that though superior persons sometimes scoffed at his exhortations, "he had a firmer grasp and often a deeper grasp of essentials than they." The *Daily News* (January 7, 1919) revealed how Roosevelt, as a public speaker, had a way of "carrying his audience with him by his interesting arguments, and of persuading them that he was saying something most profound, when as a fact, he was only retelling familiar truths." The London *Observer* (January 12, 1919) contended that the English were not accustomed to Roosevelt's bombastic manner. They were unaware of his unbounded conviction and of his unlimited earnestness, and so were prone to look upon his platform performances as "somewhat theatrical." The London *Times* (January 7, 1919) lauded the ability with which Roosevelt held fast to the American people and pointed out how he taught his fellow Americans in a "language everywhere understood by the people." The London *Spectator* (Anonymous, 1919a) expressed the same idea. When Roosevelt spoke "everyone knew what he meant." While one might agree or disagree with him, no one could pretend not to understand him. "He was a plain speaker if there ever was one." James Whelpley an English reporter who knew Roosevelt well, described him as a "Radical talker and a conservative actor . . . his bark was worse than his bite" (1918).

Many spoke of Theodore Roosevelt's undaunted courage. The London *Times* (January 7, 1919) found him absolutely fearless. Although frequently tactless, he succeeded by his cordial geniality and by his large humanity. The London *Nation* (Anonymous, 1918-1919) entitled its more than two page article about Roosevelt "Ever a Fighter." He was a born fighter "and the cloak of righteousness was for him a shield and a buckler." He carried a furious fighting quality into "every section of his strenuous life." Yet for one who stood for "deeds not words," the lavish outpouring of

Roosevelt's pen and tongue in endless flow on an infinite variety of topics would seem an inconsistency to those who did not realize the great part mere "talk plays in the great Republic of the West." Furthermore, concluded the liberal *Nation,* (ibid.) there was a place in America for strong, vigourous, courageous men and Roosevelt surely did try to create such a niche for himself. That Roosevelt fought his fights clean and fair was the studied opinion of the London *Daily News.* (January 7, 1919)

Several British journals noted Roosevelt's tendency to preach. The *Daily News,* (ibid.) informed its readers that on occasion when addressing a political meeting, he let slip the phrase, " 'But O' my Brother' and immediately joined in the shout of laughter against himself." If he preached, his sermon was customarily on the subject "Sweat and be Saved." According to the London *Observer,* (January 12, 1919) Roosevelt exemplified the highest type of courage before the American people and they followed him as an apostle of all that stood for a clean, high, strenuous standard of life. His universal tendency to preach, concluded the *Nation,* (Anonymous, 1918-1919) may be traced to the traditional Puritanism of America which resulted from the strange blending of blood and manners in large sections of American society. This weekly journal of current opinion did not think highly of Roosevelt's oratory, calling it "intolerable reading." The *Nation* (ibid.) was at a loss to understand how "Roosevelt's magnetic personality could carry multitudes through such an ordeal of his platitudiousness preaching."

P. W. Wilson, writing in the London *Daily News,* (January 7, 1919) said that Theodore Roosevelt was a life-long crusader. The London *Daily Mail* (January 7, 1919) thought that Roosevelt had lived long enough to realize that he was "something of a prophet." In short, his preaching had not been in vain.

English periodicals did not hesitate to point out flaws in Roosevelt's personality. For example, James D. Whelpley wrote in the *Fortnightly Review* (1918) that with Roosevelt, "more than in any other successful public man in modern history, it was always a case of 'you are either for or against me, and if against me you are no friend of mine." He has never forgotten nor forgiven a slight nor injury, whether intended or inadvertent." The former president insisted upon absolute personal domination; he was content with nothing less. The *Nation* (Anonymous, 1918-1919) thought that

as a resident of the White House, Roosevelt had the temper of a patriarch rather than that of a President and that he never felt a need to take advice from others who frequently were better qualified to know the situation than was he. One journalist thought it impossible for Roosevelt to have had a highly developed sense of humor, "for no one who took himself as seriously could afford it." A sense of humor would have intruded itself at critical moments and weakened his overpowering self-confidence which at times was his sole dependence (Whelpley, 1918). He had an "old Testament zealousness for punishing his enemies and for regarding those whose views were different from his as wicked men," stated the *Natio*n (Anonymous, 1918-1919).

The London *Times* (January 7, 1919) sought to evaluate Roosevelt's mind. The editor did not believe that he was "an original thinker" but added that the man was a thinker "whose thoughts became acts," because they were eminently the thoughts of a man whose preaching was moral precepts and whose teaching was plain morality. Indeed, the "morality he preached was quite simple: That was why it made such a strong appeal to his audiences of the most different characters. It was the old-fashioned Christian doctrine of the most elementary type applied to every day things of public and social life. The *Fortnightly Review* (Whelpley, 1918) told of Roosevelt's being a "voracious and serious reader" and of his possessing a "remarkable memory for all he has seen, heard, or read."

Quite a few voices of British opinion reminded the reading public of some of the numerous anecdotes connected with Roosevelt's public life. A volume could be filled with Roosevelt's precious anecdotes, said the *Fortnightly Review* (ibid.), adding that each one would throw a light on some particular facet of his many-sided nature. Each anecdote would give in a quiet way "an impression of the man as a whole" to anyone who wished to understand or judge him on that evidence alone. The *Daily Telegraph* (January 7, 1919), told of the prayer that eminated from Wall Street the day in the spring of 1909 that the recent President sailed for his African safari: "Wall Street expects every lion will do his duty." It also quoted a famous member of Congress who, when speaking sarcastically of Roosevelt's high public morality, as saying "that he envied the President in his discovery of the Ten Commandments."

One member of the British metropolitan press spoke of the "Cult of Teddy" that arose in America and "gradually spread all over Anglo-Saxondom." That unusual and beloved companion of children, the "Teddy Bear" became a symbol of the mingled affection and amusement with which the plain American citizen regarded his sportsman President. Moreover, Roosevelt was the only President of the United States to give his name to a garment of clothing, for the ladies, not to be outdone by the little children, had their teddies, too. There were, however, some contrasts.

Roosevelt's mind, thought the correspondent James Whelpley, was a "varied landscape with fine heights, low-lying valleys, sweetened bitter syrups, worked and waste land having upon it life-giving and poisonous plants and yet as a whole it was pleasing to the eye" (Whelpley, 1918). Indeed, such an intellectual variety was seldom given to one personality, and especially to one who occupied several high elective positions. The *Nation,* (Anonymous, 1918-1919) impressed upon its readers the great variety of Roosevelt's mental curiosity and his intellectual venturesomeness. This restless and active mind had about it a ruthlessness, and intolerance of low vitality and a completeness of self-confidence that was startling. He was the grand American raised to the highest power. Granted that Roosevelt had a master mind and that he possessed a photographic memory, James Whelpley bore witness that he could and did achieve really great things but that he sometimes strayed to "trivialities that astounded even those who admired him most" (Whelpley, 1918). P. W. Wilson, writing in the *Daily News,* (January 7, 1919) told of Roosevelt's ability to come immediately down to the brass tacks of any question under discussion. No British periodical, however, challenged the conclusion of the London *Times,* that Theodore Roosevelt could not be "ranked with the lofty creative geniuses" of modern times. (January 7, 1919)

Only the weekly journals of public opinion mentioned Roosevelt the family man. His devotion as a husband, his companionship to his children, especially to his several sons, went unnoticed except for a brief statement in the *Nation* and in the *Fortnightly Review.* The *Nation* (Anonymous, 1918-1919) acknowledged that he was "admirable in his family and close personal relations." The *Fortnightly Review* (Whelpley, 1918) was equally brief: "no man outside Roosevelt's immediate family was ever able to say truthfully that he was on really intimate terms with Theodore Roosevelt."

Only the London *Daily News* (January 7, 1919) thought well enough of Roosevelt as a journalist to preserve in English opinion his manifesto of ideal journalism. Roosevelt issued it at the beginning of his editorship of the New York *Outlook*: "During the last few years it has become lamentably evident that certain daily newspapers, certain periodicals, are owned and controlled by men of vast wealth who have gained their wealth in evil fashion, who desire to style or twist the humblest expression of public opinion, and who find an instrument fit for their purpose in the guided and purchased mendacity of those who edit and write such journals."

In the opinion of the London *Daily News,* (ibid.) there was no question that Roosevelt would be accorded by posterity a place among the great Republican Presidents. Indeed, he was a "single example in the history of the United States of a Vice-President succeeding automatically to the Presidency officially and attaining distinction in it." Roosevelt, "by breeding and education," said the *Spectator* (Anonymous, 1919b) belonged to the American wealthy classes which in English do not take much part in the "rough and tumble of politics, but America has never been served by a truer democrat than by Roosevelt." Continuing, this review of politics, literature, theology and art, observed that as a man of large ideals, "who stood for public morality and national honor, Roosevelt seemed to be one of the great assets of the English-speaking races." The London *Times* (January 7, 1919) observed that in politics as in everything the T. R. was a fighter. He preached with the same bluntness and the same transparent conviction to the *intellectuals* of Paris at the Sorbonne or at the University of Oxford as to the back-country rustics in the American West. Upon Roosevelt's death, declared the *Daily Chronicle* (January 7, 1919) there departed "a voice at once stimulating and disturbing, and a personality which was unique in the American Nations." Certainly he was a national influence.

P. W. Wilson thought that Roosevelt's personal following was astonishing. He was easily the most popular of American speakers "and this was all the more remarkable because between his orations, there was a certain similarity." As Roosevelt said to Wilson, he knew to a nicety what the Americans, with a materialist crust over their genuine souls, "were thinking, and how far their mental processes had gone in any direction." As a foreigner who had

traveled widely in America, Wilson was struck by Roosevelt's popularity. The Colonel would be terribly missed. "Many Americans loved him as a friend. The youngsters worshipped him as an ultimate hero. Women blessed him, none the less because differing with old political wire pullers, he preached the duty of rearing large families" (London *Daily News*, January 7, 1919).

Of all Englishmen who sought to evaluate Theodore Roosevelt's political accomplishments, none approached the keen insight attained by James D. Whelpley. Writing in the London *Westminster Gazette* (January 8, 1919), he stated that Roosevelt had come to the presidency "when commercialism in politics was threatening the political and social structure of the nation. Thoughtful men were cynical in regard to public office, some had begun to question the real values of the American form of government and were quite prepared to argue its failure. Great industrial and financial interests dictated to Congress; State Legislatures and law courts were swayed by these powers to serve their wills." Coming to the White House amidst such conditions T. R. soon issued his declaration of principles. And, continued Whelpley, the fresh air that President Roosevelt led into the political situation soon developed into a hurricane in which practically everything floundered that was not honest in intention and sound in principle."

Although his administration was born in violence and destined to turbulence, the welfare of all the people, with him stood superior to the interests of the selfish few. The London *Times* (January 7, 1919) expressed somewhat the same idea by saying that he carried out his policies steadily and tenaciously, "but he carried them out with a caution and a grip of the practical which again and again baffled the political 'old gang'."

Roosevelt's career, the *Nation* (Anonymous, 1918-1919) thought, presented a person of "universally powerful interests and emotions" entirely obedient to the narrow aims of social conduct within modern statecraft. The London *Daily Mail* (January 7, 1919) contended that he was a man of "will and energy, who fought against 'graft' and privilege, who said what he thought intently and forcibly, whose range was wide and life vital, a man who made a great place in the world, as well as at home, by the dint of great and very American qualities."

Voices of British public opinion spoke glowingly of Theodore Roosevelt's dedication to social reform. The London *Times* (January 7, 1919) for example, said that: "The torch of social reform which he lighted continues to burn." The only danger was that it "may burn too rapidly and with too much fierceness." Moreover, this independent liberal newspaper thought that "Roosevelt himself had no more sympathy with predatory Socialism than with the Monopoly of trust." He saw the danger of any one class or group dominating in America. He was a foe of all corruption and graft, averred the London *Daily News* (January 7, 1919). The people were delighted with the reforms that President Theodore Roosevelt wrought in the United States. "Strong common sense and moderation characterized the body of far-reaching changes which he effected in internal politics" (London *Times* January 7, 1919). The *Nation* (Anonymous 1918-1919) spoke of Theodore Roosevelt as a "fearless enemy of grafters, the rooter-out of corruption . . . the apostle of the 'square deal' for the working man [and as one whose] Puritan principles and combativeness did excellent service in the cause of 'righteousness' in politics." James D. Whelpley, in the *Fortnightly Review* (1918) emphasized the 'tremendous hold upon the imagination of the people" which T. R. attained and held for years. This fortunate achievement, thought Whelpley, was due to the fact that "no President ever had more attentive ears to the real needs of the nation than did Roosevelt. As Chief Executive he had an uncanny skill and presience as an interpretor of the National voice." It was in this field of unselfishness that T. R. achieved his "greatest service to the nation; an accomplishment so great; so entirely beneficial and so far-reaching in its consequences as to belong properly to the category of epoch-making events in the history of the United States." The Manchester *Guardian* (January 7, 1919) referred to Roosevelt's denunciation of corruption, to his agitations against the trusts and added that his "pronouncements were lay sermons, vigorous and abundant like the man himself," but they lacked legislative proposals for precise remedies. It was his "personality rather than anything he achieved which made him figure so large among his contemporaries." The studied conclusion of the *Guardian* was that "sterility marked Roosevelt's administration."

The *Spectator* (Anonymous, 1919b) contended that Roosevelt's mission in a period during which the United States had become a

world power without knowing it, was to "infuse a new spirit into America's politics, and to arouse her to a sense of her changed position in the world." In the Roosevelt Presidency America "learned to think internationally, if not imperially." The *Daily Telegraph* (January 7, 1919) was of the opinion that Roosevelt, in the domain of foreign policy, left "a permanent mark upon American history. At the end of his second term as President his Country "was conscious of itself and its responsibilities as a power as it had never been before. According to this source, no person did as much as Roosevelt himself to introduce the spirit of world power to the American people. His famous phrase for the right diplomacy of national greatness in a world of competing ambitions was "to speak softly and carry a big stick." It summed up the wisdom of generations in the Old World.

The popular provincial Manchester *Guardian* (January 7, 1919) with liberal proclivities, announced that Roosevelt brought into "world politics something of the wind of the great prairies." As President he stood at a parting of the ways for America; both internally and externally, the United States was passing through a great transition. Into this new atmosphere he projected, especially in foreign affairs, a noisy "primitive American individualism." The London *Times* (January 7, 1919) thought Roosevelt's international relations were those of a "shrewd politician and a sensible man of the world." Sir Robert Borden told of Roosevelt's great place, not only in his own country, but in the wider theaters of world affairs, as well. He recalled the "remarkable reception" accorded Theodore Roosevelt in Canada as testimony of the affection and esteem in which the American President was held by the people of Canada (London Westminster *Gazette*, January 7, 1919). The *Nation* (Anonymous, 1918-1919) declared that for 20 years Roosevelt had gone about preaching the responsibility of the strong nations to govern the weak justly. The expansive zeal of T. R.'s moral message, overrode all considerations of freedom or self-determination in the western hemisphere, with "a spirit of Imperialism ever more dangerous to the order and liberty of the world than any of the more blatant brands prevalent in Europe." Indeed, said this weekly periodical, Roosevelt's coercion of the Middle and South American States was a "rigorous exploitiation of the Monroe Doctrine." Moreover, that Roosevelt should receive the Nobel

Peace Prize as a peace-maker "was a given commentary upon such a life." The *Fortnightly Review* (1918) believed that in international crises Roosevelt found full play for "all those qualities of military patriotism, law of action, and quick play of mind," which he exemplified to an unusual degree.

The *Spectator* (Anonymous, 1919b) praised the service Roosevelt rendered the British in the Venezuelan Controversy but thought the incident which gave him the best opportunity to show his force of character and to display his courageous action was the Panama Canal crisis: "The Panama Canal was his chief monument, his greatest work in the eyes of American public opinion." The London *Daily Chronicle* (January 7, 1919) agreed with the *Spectator* that the "Canalization of Panama" was his greatest achievement. The *Nation*, (Anonymous, 1918-1919) however, spoke indignantly of Roosevelt's "secret fomentation of an insurrection in Colombia in order to set up a State of Panama which he should straightway recognize as qualified to convey to America a zone of land required for making of the canal." This episode, continued the liberal weekly, "caused Roosevelt not a qualm. He defended it on the pure grounds of urgent public interests." In short, concluded the *Nation*, the Colombian government "corrupt and obstructive to the interests of the United States must be coerced into submission.

What was the greatest significance of Roosevelt's presidential administration? British voices of public opinion had some conclusions about this question too. The London *Daily News* (January 7, 1919) informed its readers that he had dominated his "cabinet and the Congress alike by the force of his personality (and that) he set a new standard in Presidential initiative." The *Daily News*, however, went on to say that Roosevelt left a less enduring mark in the United States than at one time seemed likely. "His great achievement, the creating of the separate Progressive party out of the Republican left wing, has already come to nothing. James D. Whelpley, foreign news correspondent in Washington, stated that Roosevelt's friends believed his administration was one of the greatest in the history of the Presidency. The English reporter contended, however, that T. R. was never really liked by the newspaper men (*Fortnightly Review*, 1918). The London *Observer* (January 12, 1919) thought it would be most difficult to state precisely the sig-

nificance of Roosevelt's administration but that he stood for the "ideals of modern America." James Whelpley contended in the *Westminster Gazette* (January 7, 1919) that it was "as a revolutionary leader, and as a savior of his country in times of dire need that Roosevelt stood forth as a tremendous figure in American history." No one, thought this daily newspaper, could conceive of the drastic changes that had come about in American life since 1901 without realizing Roosevelt's significance. The power of money was crushed, monopolies were largely abolished and the rights of property were held to be so administered. It was a far cry from the conditions of the pre-Rooseveltian days. It was, concluded the *Westminster Gazette,* to Theodore Roosevelt, "the democrat-aristocrat, the American people owe their transition". The Glasgow *Herald* (January 7, 1919) declared that if one is ever tempted to think of the failure of democratic institutions, it was a "reinforcement of faith to recall the distinguished plane on which the Presidency of the great Republic has been almost uniformly mentioned—and by none with more honour than by Theodore Roosevelt."

Several British papers expressed themselves quite frankly about the relationship between Theodore Roosevelt and Woodrow Wilson. The *Daily Telegraph* (January 7, 1919) noted the vigorous criticism by Roosevelt of the Wilsonian policy of neutrality but refrained from indicating which of the two Americans had chosen the more statesmanlike course. It was enough to say that once America was committed to the war Roosevelt gave President Wilson "the heartiest support and his only public difference was a general appeal, which the military authorities at Washington could not grant, for leave to take a force to the front." The *Spectator* (January 11, 1919) divulged the wide differences "in temperament and methods" between the two men and announced that though they were wholly dissimilar, yet Wilson was carrying on the work begun by Roosevelt; and "showing the world that America with her mighty power must have a great share in the attainment of a stable peace." The Manchester *Guardian* (January 7, 1919) never strongly Rooseveltian, declared that it was Woodrow Wilson who carried out the "Constructive reforms, constitutional and financial, and who won the enduring loyalty of forward-looking men in America." Indeed, concluded the *Guardian,* it was the "Great War and President Wilson which brought America forthwith into

the sweep of world affairs." Yet another British voice averred that Roosevelt's severe criticism of Wilson's diplomacy, "whether judicious or not, was animated by a keen desire that America should play a vigorous and unhesitating role in the struggle for Justice and Right." The Glasgow *Herald,* (January 7, 1919) noted the vast temperamental differences that intensified the political antagonisms between Roosevelt and Wilson, but did not say which nature was best fitted to make the solemn decisions America was destined to formulate. Suffice it to say, concluded the *Herald,* that Wilson never had a more courageous opponent to his policies and no more generous aid to get public opinion solidly for war than Theodore Roosevelt. Actually, Roosevelt pushed the Coach to which the President was harnessed. Although Roosevelt's departure left a gap in American statesmanship, his loss was not irreparable in a country which produced Woodrow Wilson as one of his contemporaries. The London *New Statesman,* in an editorial, spoke of Roosevelt as "one of the world's most forceful personalities," and as having been the probably Republican choice for the Presidency in 1920. It added that his death "practically extinguishes any chance of President Wilson, who would himself have been a 'third term candidate,' from becoming the choice of the Democrats." Moreover, affirmed this weekly of liberal opinion, if both of the American political parties had agreed on such candidates the unbroken tradition of the Republic which barred a second presidential reelection would have been overcome. The *New Statesman* (January 11, 1919) thought the consequences to Great Britain and Europe were even more momentous. President Wilson, with no chance of a third nomination, will "let himself go" in the promotion of the policies with which he has identified his own personality "and for which not only the Labour and Socialist Movements throughout the world, but also the Churches, and the intellectual forces generally turn increasingly to him with so much hope."

It is quite natural for the voices of British opinion to express themselves on the attitude which Theodore Roosevelt held towards them and their government. King George V cabled Mrs. Roosevelt that her distinguished husband would be missed by his many friends in Great Britain (King George V, 1919). The London *Times* (January 7, 1919) rejoiced in the fact that he maintained "that every dispute between the United States and Great Britain

should be settled by arbitration." His anxiety for the closest friendship between the English speaking peoples was frequently commented on by the British agencies of public opinion. The *Times* was especially pleased with the stand that T. R. took when the Germans invaded Belgium in August, 1914: "But when he drew the sword in defence of outraged Belgium and for the protection of our liberties, his whole heart went out to us." Frank Dilmot wrote in the London *Daily Chronicle* (January 7, 1919) that he undoubtedly was a great influence in bringing the American people into line for participation in the European war. Editorially, the *Daily Chronicle* (ibid.) stated that "we on this side shall not soon forget the whole-hearted sympathy which he expressed for the Allies in the darkest days of their struggle against Kaiserism." The London *Daily Mail* (January 7, 1919) while admitting that the British were "remarkably and culpably ignorant of American politics," yet they knew that they had lost a dear friend in Roosevelt's passing and they were sad. The Manchester *Guardian* (January 7, 1919) also appreciated the role he played in making the American people war-conscious and added that Roosevelt did not make the war, "he mirrored it." The *Guardian* felt that no doubt a very strong personal and political dislike for President Wilson explained the fury of T. R.'s onslaught upon Wilson's policies, especially upon the idea of a League of Nations. His actions were also due to his "temperamental distaste for constructive thinking, his shrinking from organized cooperation and his instructive faith in personality and individualism and what he would call virility; as a panacea for all public ills" (ibid.). According to the London *Daily News* (January 7, 1919) Roosevelt was a protagonist in America for fair play towards Britain. James D. Whelpley concluded that without knowing it Roosevelt was preparing America "to become the fit and proper champion for the cause of the Allies, which is the cause of humanity" (*Fortnightly Review*, 1918). "The English", stated the *Westminster Gazette*, (January 7, 1919) "were among those who admired him for his splendid vigor in public life." The *Spectator* (Anonymous, 1919b) declared that "as an American patriot, no less than an advocate of a closer British American understanding, Roosevelt urged that America must intervene in the scale against Germany." Throughout an extended public career, Roosevelt "held firmly to the idea of the essential unity of the English-speaking

peoples." According to this weekly review of public opinion, the British felt that if Roosevelt had not been an American "he might have been an Englishman." The *Review of Reviews* (Anonymous, 1919a) summarized British thought well when it declared that Roosevelt's "whole-hearted sympathy during these last bitter years will not soon be forgotten on this side of the Atlantic."

The London *Daily News* (January 7, 1919) lamented that the death of Roosevelt robbed the world of one of its "most versatile personalities." John Steele wrote in the *Illustrated London News* (January 11, 1919) that there had been few men whose careers were more difficult to summarize in detail than that of this "picturesque statesman, author, rancher, soldier, explorer, hunter, publicist, and world-renowned exponent of the 'strenuous life'." The *Nation* (Anonymous, 1918-1919) summarized its feelings by saying that he was "simply the grand American raised to its highest power."

All of these have been individual impressions of Theodore Roosevelt expressed in agencies of mass media. There were personal evaluations of T. R. revealed in private communications. Of these we have time for only a sampling. Sir Frederick Pollack wrote his aging friend Justice Oliver Wendell Holmes that Roosevelt's split with Taft "may have been his one bad mistake, but the causes are obscure to us here . . . If only he could have been your war President; he had something of a blind spot for the legal point of view and the distinction between legal and political justice, but that would not have mattered for the war" (Pollack, 1924). Harold J. Laski, back in England from a recent visiting professorship at Harvard confided to Holmes that Roosevelt had enjoyed "a rich and full life." He had made his mark; and for the last decade he had spent his "energies in comment instead of observation." His progressivism wasn't real in the sense of implying basic change; but "it was the kind of plea near enough to your coachman and tailor to make them feel uplifted by it." This intelligent English liberal summarized T. R.'s public career by saying "what a gloriously simple world he lived in. If you agreed with him, you were a noble fellow; if you disagreed you were a low blackguard" (Pollack, 1924). James Viscount Bryce wrote the imminent American historian, James Ford Rhodes that the British were much grieved at the news of Theodore Roosevelt's death. Roosevelt, said Bryce,

"had defects of his qualities, no doubt . . . but he had fine ideals and there was a great fascination about his personality . . . He had many wide-ranging versatile interests. I fear his energy wore him out" (Bryce, 1920).

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Diel Periodicity of Chlorophyll *a* in the Gulf of Mexico

Walter A. Glooschenko

Diel variation of chlorophyll pigments *in situ* in marine waters has been observed by several researchers. In the Pacific Ocean and its adjacent waters, such phenomena were observed by Shimada (1958), Yentsch and Scagel (1958), and McAllister (1964). In the Atlantic Ocean, Yentsch and Ryther (1957), Ryther, Menzel and Vaccaro (1961), Lorenzen (1963), and Wood and Corcoran (1966) found diel pigment variations. In the Antarctic Ocean, the phenomenon was observed by El-Sayed and Mandelli (1965). Studies of the distribution of chlorophyll in the Gulf of Mexico were carried out by Marshall (1956) and Steele (1964), but they did not investigate diel variations of this pigment.

The time of maximum chlorophyll concentration varies. Yentsch and Scagel (1958) and El-Sayed and Mandelli (1965) found maxima to occur at night while the other authors previously mentioned found *in situ* maxima to occur during daylight with minimum concentrations at night. The purpose of the present study was to investigate the diel variation of chlorophyll *a* in the Gulf of Mexico.

Methods and Materials

Two stations in the Northeast Gulf of Mexico at 28°0′N, 85°0′W and 28°36′N, 84°21′W were occupied with the R/V *Tursiops* of Florida State University. The first station was at the edge of the continental shelf at 340 m water depth, the latter section at Florida Middle Ground on the shelf at a water depth of 35 m. Surface temperatures averaged 24 C, and all samples were taken above the depth of the seasonal thermocline as determined with a bathythermograph. Seas were calm at both stations with a cloud cover of no greater than 10 per cent.

Water samples were collected with a Niskin water sampler at several depth intervals at time intervals of 2-4 hours. Four liter quantities of water were filtered through a Millipore HAWP 0.45 micron pore-size membrane filter to which 1 ml of saturated $MgCO_3$ was added. Filters were then placed in a dessicator at −20 C until analysis. They were then homogenized in 3 ml of

cold 90 per cent acetone in a Sorvall Omni-Mixer for 3 minutes, made up to 10.0 ml volume with the acetone in a calibrated glass centrifuge tube and centrifuged for 10 minutes at 3500 rpm to remove all debris and $MgCO_3$ particles. This technique is similar to that of Strickland and Parsons (1968) with the exception of the use of the homogenizer. Chlorophyll *a* was then determined spectrophotometrically with a Beckman DB-G spectrophotometer using the equation of Strickland and Parsons (1968).

RESULTS AND DISCUSSION

Several explanations have been given for observed diel variations of chlorophyll. These include grazing (McAllister, 1963; Wood and Corcoran, 1966) and light (Yentsch and Scagel, 1958). Yentsch and Lee (1966) concluded that the chlorophyll content of phytoplankton represented a balance between photo-oxidation at high light intensities and pigment synthesis. They believed that surface phytoplankton were able to reduce chlorophyll concentrations in the afternoon to prevent harmful photo-oxidations.

Changes in diel chlorophyll *a* at the two Gulf of Mexico stations indicate that light intensity appears to be the major control of *in situ* minimum concentrations of this pigment. At the first station, chlorophyll *a* concentration minima occurred in the afternoon hours at the surface, at 10 m and 30 m depths (Fig. 1). At the 50 m depth, maximum chlorophyll was observed during the late afternoon and early evening hours. Chlorophyll *a* concentration at the surface, 10 m and 30 m increased in the early evening hours with maxima occurring before midnight. If grazing were a major control of chlorophyll *a* at this station, the concentration of this pigment should have decreased at night when grazers were in the surface waters. No indication of such phenomena was observed at the 10 m depth, but some decreases did occur at the surface, 30 and 50 m.

At the second station (Fig. 2) minimum chlorophyll *a* concentration occurred at the surface in the morning, and at the 10 and 20 m depths the minimum concentration occurred in the afternoon. At this station, it appeared that the high light intensities in the afternoon causes the minimum concentrations of chlorophyll *a* at that time at the 10 and 20m depths. This confirms the paper of Yentsch

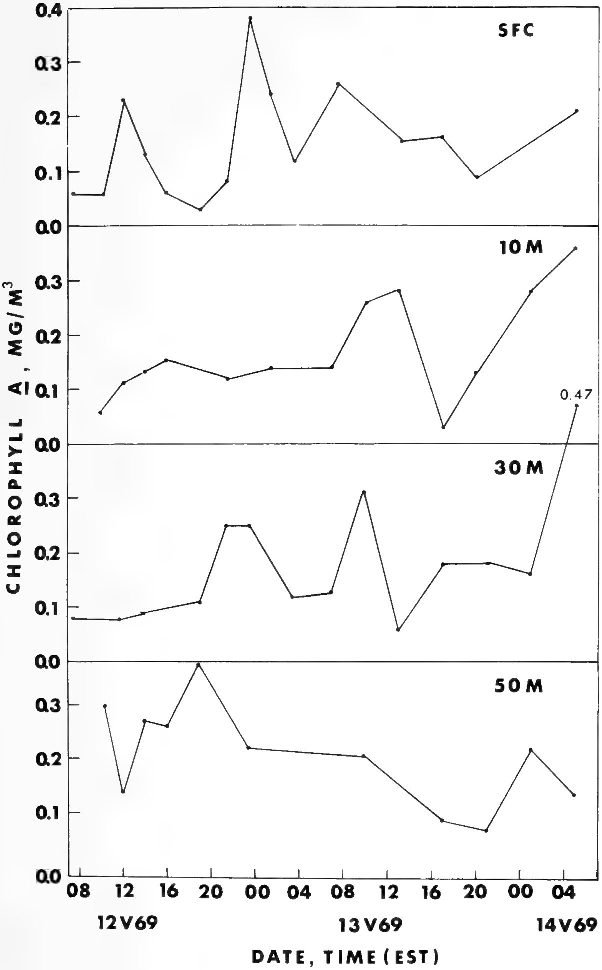

Fig. 1. Chlorophyll *a* vs. time, depth. 28°0′N, 85°0′W.

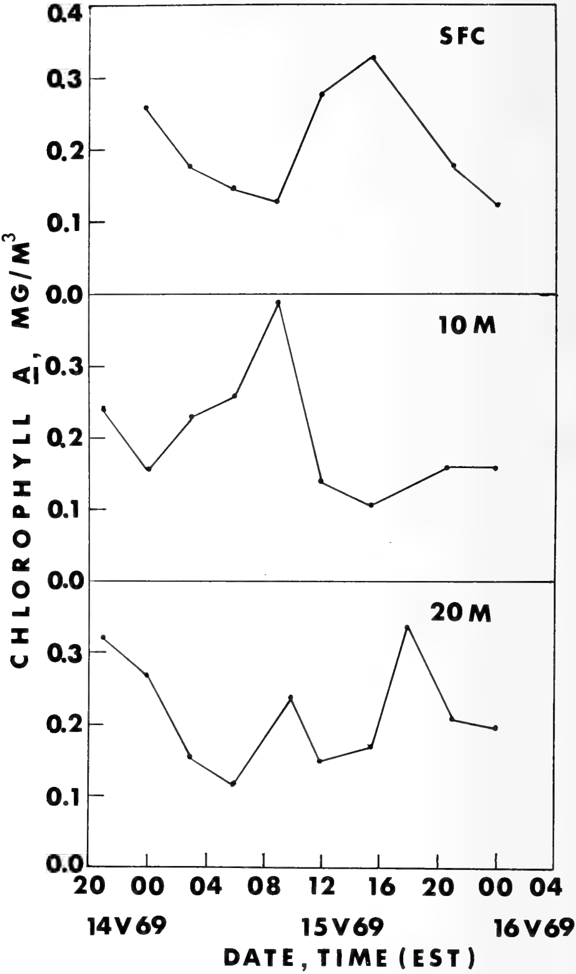

Fig. 2. Chlorophyll *a* vs. time, depth. 28°36′N, 84°21′W.

and Lee (1967). However, the afternoon chlorophyll maximum occurred at the surface in contrast to the other station.

If grazing was a major control of diel variations of chlorophyll *a* concentration, minimum concentrations should occur at night as observed by McAllister (1963) and Wood and Corcoran (1966). There is indication of this at the second station and on the night of May 12 on the first station. However, the amplitude of this variation appears to be too great to be explained by grazing. Ratios of maximum to minimum chlorophyll *a* concentration in this study varied from 2.5-12.7 with an average of 6.5. This would mean that using such an average, approximately 15 per cent of cells would remain after the period of grazing, and nearly three cell doublings per day would have to occur for the cell population to regain its former value. This doubling rate is much too fast for natural conditions according to the work of Eppley and Strickland (1968). These authors listed mean doubling times in the oceans of 4-5 days. Also, at the first station on the night of May 14, chlorophyll *a* concentrations increased at night indicating dark synthesis. No indication of grazing was seen here. Thus, grazing appears to be a minor control for chlorophyll *a* decrease at night in the Gulf of Mexico, and light, the major control of observed pigment changes during the afternoon.

This observation also shows that the use of chlorophyll *a* for a measure of standing crop of phytoplankton is of doubtful utility unless samples were collected at the same time of day to correct for diel variations under similar light conditions and grazer concentrations.

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Two New Atlantic Clinid Fishes of the Genus *Starksia*

Carter R. Gilbert

The clinid genus *Starksia* Jordan and Evermann comprises a group of New World marine fishes that is characterized by having internal fertilization. The first anal spine in adult males is modified into an intromittent organ, the gonopodium, and the morphology of this structure has been shown (Böhlke and Springer, 1961; Rosenblatt and Taylor, in press) to be of fundamental importance in determining species relationships. Because of its mode of reproduction, the genus has been assumed to be viviparous (Al-Uthman, 1960). Recent studies have shown, however, at least four eastern Pacific species to be ovoviviparous (Rosenblatt and Taylor, in press), although this has not yet been proved for any Atlantic species.

Prior to Al-Uthman's (1960) and Böhlke and Springer's (1961) reviews of the eastern Pacific and western Atlantic species, respectively, only seven species of *Starksia* were recognized, all but one of which were from the western Atlantic. One new Pacific and two new Atlantic forms were described in the above papers, and an additional Atlantic species was later named by Gilbert (1965). Recent fish collections have resulted in 10 more species, three from the Atlantic and seven from the Pacific. Two of the Atlantic species are described in the present paper, and descriptions of the new Pacific forms will soon be published (Rosenblatt and Taylor, in press). In addition, Rosenblatt and Taylor are describing, in the same paper, a new genus and species closely related to *Starksia*. The third new Atlantic species, which differs in several ways from other known members of the genus, is presently under study by James E. Böhlke, of the Academy of Natural Sciences of Philadelphia. The total number of valid species thus is raised to 21 (not including the new genus), of which 12 are from the western Atlantic.

The nominal genus *Brannerella* Gilbert, long regarded as a junior synonym of *Starksia,* was given generic status by Al-Uthman (1960), who listed as its distinguishing features: 1) Gonopodium (first anal spine) longer than second anal spine (shorter in *Starksia*) in adult males; 2) pectoral fin rays 14 (usually 13 in *Starksia*); 3) absence of a black spot in membrane between first and second

dorsal spines (present in *Starksia*); and 4) body size smaller and body color lighter than in *Starksia.* Böhlke and Springer (1961), in resynonymizing the two genera, pointed out that the last three characters break down in the Atlantic species, and that the anal-spine character, by itself, is not sufficient for generic recognition. Should *Starksia* and *Brannerella* continue to be regarded as distinct genera, other equally distinctive morphologic characters found in certain western Atlantic species (e.g., presence or absence of an orbital cirrus; other modifications of the intromittent organ) would necessitate recognition of at least two more genera.

The purpose of this paper is 1) to describe two new species of *Starksia* from Florida and the Bahamas, respectively; 2) to update the key given by Böhlke and Springer (1961) for the western Atlantic members of the genus; 3) to provide additional distributional data for the western Atlantic species; and 4) to provide additional meristic data for *Starksia hassi,* which had previously been known from only eight specimens.

Materials and Methods

Counts and measurements follow Hubbs and Lagler (1958), except for those modifications noted by Böhlke and Springer (1961). The main difference in the latter's methods concerns the segmented rays in the dorsal and anal fins, in which all elements are counted rather than tallying the last two as a single ray. One measurement additional (pectoral-fin length) to the eight used by Böhlke and Springer (1961) has been included in this paper. In contrast to the procedure of the last authors, counts are broken down in the two new species, so as to indicate number of pored and unpored scales in the arched portion of the lateral line. In the lists of material examined, the catalogue number appears first, followed by the number of specimens, sex (when known), size range in standard body length (SL), and pertinent locality data. All specimens were collected using rotenone-based fish toxicants (Chem Fish).

The following abbreviations of collections are used in listing material examined: AMNH, American Museum of Natural History; ANSP, Academy of Natural Sciences of Philadelphia; UF, University of Florida (Florida State Museum); UMML, Institute of Marine and Atmospheric Sciences, University of Miami; USNM,

United States National Museum. I wish to thank the individuals in charge of those collections from which specimens were examined for making this material available. I also wish to thank C. Lavett Smith, American Museum of Natural History, Walter A. Starck, II, and Philip C. Heemstra, University of Miami, all of whom helped collect specimens of the new species; and Russell Parks, University of Florida, who took the photographs and also aided in the field work. Collections of the new Bahaman species were made during cruises of the Lerner Marine Laboratory vessel *J. A. Oliver*, operating with funds supplied by ONR grant no. 552(07). The cooperation of the Bahaman government, for furnishing collecting permits, and of the authorities of the Lerner Marine Laboratory (particularly the director, Dr. Robert F. Mathewson) is gratefully acknowledged.

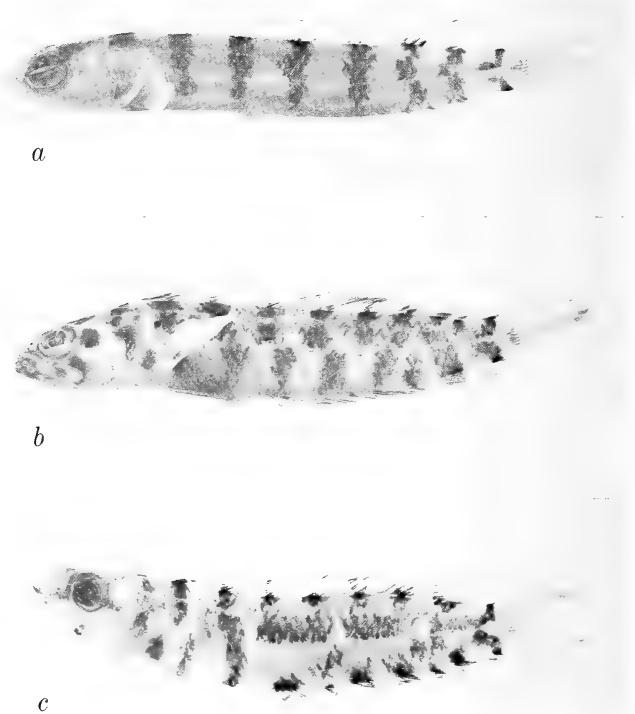
Starksia elongata new species (Fig. 1A)

Holotype. UF 14134, adult male, 26.8 mm SL, south side of Rum Cay (Bahamas), near Sumner's Point, ca. 3/4 mi. offshore, depth 5-10 ft., 4 Sept. 1966, C. R. Gilbert and P. C. Heemstra (field no. G 66-43).

Paratypes (all from Bahamas). AMNH 23232 (1 male, 23.6), Cat I., off creek near Dolphin's Head, depth 8 ft, 10 Nov. 1964, C. L. Smith, H. E. Winn, and G. Offutt (field no. S 64-73); AMNH 28998 (1 male, 25.2), Ragged I., near northwest end of Nurse Cay (small patch reef), depth 10 ft, 7 July 1965, C. L. Smith and H. Tischler (field no. S 65-77); AMNH 28999 (1 female, 17.4), UMML 27336 (1 male, 21.4), USNM 205199 (1 male, 19.5), Little Ragged I., West Point, depth 15 ft, 10 July 1965, C. L. Smith, H. Tischler, and J. Strum (field no. S 65-83); AMNH 29000 (1 unsexed, 13.0), ANSP 109799 (1 female, 22.4), Acklins I., Salena Pt., depth 10 ft, 9 March 1966, C. L. Smith and J. Sohn (field no. S 66-12).

In addition to the above, a small specimen (9.0 mm), of undetermined sex, from station S 66-12 probably represents this species. It differs from other material in only having six body bars instead of seven, although this likely is a function of size and/or age. Fin rays and body scales could not be counted.

Diagnosis. A species of *Starksia* with essentially naked venter; simple orbital cirrus; genital papilla and first anal spine in adult male united along entire length, the papilla barely projecting be-



a

b

c

Fig. 1. A, *Starksia elongata* (holotype), UF 14134, adult male, 26.8 mm SL, Rum Cay (Bahamas), 5-10 ft.; B. *Starksia starcki* (holotype), UF 10874, adult female, 27.3 mm SL, Looe Key (Florida), 5-20 ft.; C,*Starksia starcki* (paratype), UF 16188, immature female, 20.3 mm SL, Looe Key (Florida), 15-25 ft.

yond tip of spine; pores from circumorbital ossifications mostly paired (biserial); dorsal rays XX-8 (2), XXI-8 (6); anal rays II-17 (1), II-18 (7); pectoral rays 14-14 (7), 15-15 (1); lateral-line scales 16+1+20 (3), 16+1+21 (4), 17+1+20 (1). Distinguished from its closest congeners, S. *ocellata* and S. *guttata,* by a longer first anal spine, which is almost twice length of second spine (instead of only slightly longer; general appearance otherwise as in Böhlke and

Springer, 1961, fig. 16), a more slender and elongate body, color pattern, and (apparently) maximum body length. Color pattern consisting of seven well defined, broadly but evenly spaced, dark brown bars on side of body, the first bar situated below third dorsal spine and the last (the hypural markings) at base of caudal fin. The only other western Atlantic *Starksia* having a similar pigmentation pattern is S. *fasciata*. The largest specimen of S. *elongata* examined, an adult male, was only 27 mm SL, whereas both S. *ocellata* and S. *guttata* reach at least 40 mm.

Description. Proportional measurements appear in Table 1. Characters listed in the diagnosis are not repeated, except where clarification is required.

Pelvic rays I,2; segmented caudal rays 13 (7+6).

Narrow simple cirri present on nape, top of eyeball, and rear margin of anterior nostril, the cirri subequal in length; teeth present on vomer and palatine bones; most or all scales of posterior part of lateral line with tubes and pores (in holotype tubes are present on all but three of last four scales); third pelvic ray not evident in unstained material; pectoral fin extending posteriorly to around base of second anal spine; pelvic fin not reaching anus; venter naked except for a few scales immediately anterior to anus; body elongate and narrow for a *Starksia*, the body depth only slightly greater at nape than at caudal peduncle.

Bars on side of body of moderate width, about half as wide as intervening light areas, the bars meeting dorsally but not ventrally; anterior three or four bars relatively straight, posterior three or four crooked; most posterior bar (the hypural marking) interrupted in center, the pigment continuing, at a 90° angle, a short distance anteriorly; a moderate-sized, rather faint spot directly posterior to and bordering middle of orbit, and a very faint spot at lower posterior corner of (but not bordering) orbit; anterior two-fifths of upper and lower lips covered by small melanophores, as is anterior fifth of gular area; small melanophores scattered on upper half of opercle; heavy concentrations of melanophores in predorsal area and on top of head behind orbits and between lateral canals; remainder of head without pigment; a very faint edging of melanophores extending along outer margin of dorsal fin, and a few melanophores in both anal and caudal fins; no pigment on pectoral or pelvic fins or at their respective bases; pigment from bars on side of body encroach-

TABLE 1

Starksia elongata: Selected measurements (in thousandths of standard length) and counts

Catalogue no.	UF 14134	AMNH 23232	AMNH 28998	AMNH 28999	UMML 27336	USNM 205199	AMNH 29000	ANSP 109799
Sex	♂	♂	♂	♀	♂	♂	?	♀
Std. lgth (mm)	26.8	23.6	25.2	17.4	21.4	19.5	13.0	22.4
Head lgth	310	318	310	333	322	328	346	321
Snout lgth	60	81	71	80	79	72	77	67
Upper jaw lgth	146	131	147	149	140	138	154	134
Eye diameter	78	85	79	92	79	87	92	80
Body depth	157	153	178	201	187	179	177	174
1st D spine lgth	90	85	99	103	107	113	115	89
Pectoral fin lgth	250	280	258	287	280	287	246	277
Pelvic fin lgth	198	191	179	224	220	221	215	214
Caudal fin lgth	216	220	238	247	—	210	262	—
Counts:								
Dorsal fin	XXI–8	XXI–8	XX–8	XX–8	XXI–8	XXI–8	XXI–8	XXI–8
Anal fin	II–18	II–18	II–18	II–18	II–18	II–18	II–18	II–17
Pectoral fin	14–14	14–14	14–14	14–14	14–14	15–15	14–14	14–14
Lateral line scales	16+1+21	16+1+21	17+1+20	16+1+21	16+1+21	16+1+21	16+1+21	16+1+21

ing slightly on base of dorsal fin, not at all on base of anal fin, except for fifth and sixth bars.

Background body color of holotype bright straw in life, the overlying pigmentation chocolate. No other colors noted.

Relationships. As noted previously, *Starksia elongata* evidently is most closely related to *S. ocellata,* a widespread species known from the Carolinas to Brazil, and *S. guttata,* which has been found only along the coast of northern South America and closely adjacent areas. For reasons discussed below, however, the relationships of *S. elongata* appear slightly closer to *S. ocellata* than to *S. guttata.* The most important feature common to the three species is the structure of the gonopodium, which is nearly identical in appearance in *S. elongata* and *S. ocellata*; the only obvious difference is that the length of the first anal spine is nearly twice the length of the second spine in *S. elongata,* whereas in *S. ocellata* the first spine is only slightly longer (Böhlke and Springer, 1961, fig. 16). *S. guttata* apparently differs from both in having the genital papilla projecting slightly farther beyond the tip of the spine (Böhlke and Springer, 1961, fig. 14).

Fin-ray and scale counts in the three species are virtually identical, the only possible differences being that no specimens of *S. elongata* were found to have either 19 anal soft rays or 22 scales in the straight portion of the lateral line, whereas these counts are common in *S. ocellata* (Böhlke and Springer, 1961, table 6); however, the number of specimens of *S. elongata* presently available (eight) is much too small to reach any definite conclusions on this point. Other important similarities concern the paired (biserial) arrangement of pores on the circumorbital ossifications; the narrow, simple cirri on the nape, eyeball, and rear margin of the anterior nostril; and the absence of scales from all but the posteriormost part of the venter.

In addition to its gonopodial structure, the geographic distribution of *S. elongata* suggests a closer phylogenetic relationship to *S. ocellata* than to *S. guttata.* It is more parsimonious to assume derivation of *elongata* either directly from *ocellata* or from a common ancestral form living in the Florida-Bahamas area, than from the geographically more distant *S. guttata.*

Ecology. All specimens of *S. elongata* were collected from small to medium-sized coral formations in shallow water (5-15 ft)

of the southern Bahamas. Other species of *Starksia* taken at the type locality include *S. atlantica, S. fasciata,* and *S. lepicoelia.* Although the closely related *S. ocellata* also is a reef dweller, it seems to occur only in areas having some degree of continental influence (Gilbert, in press). All of the islands from which *S. ocellata* was recorded by Böhlke and Springer (1961, pp. 55-56) have, in contrast to the Bahamas, a high relief, and thus surface runoff (and consequently some water turbidity) is often present.

S. elongata appears to be a rare species and also one of restricted range. It is surprising that only eight specimens have, till now, been recorded from the hundreds of shallow Bahaman reef collections. Inasmuch as the northern Bahamas have been particularly well surveyed, it seems reasonably certain that the species is not present there.

Etymology. The species name *elongata* is in reference to the unusually slender and elongate body.

Starksia starcki new species (Figs. 1B and 1C)

Holotype. UF 10874, adult female, 27.3 mm SL, Looe Key, ca. 4½ mi. SSW of Little Torch Key (and US hwy. 1), Monroe Co., Florida depth 5-20 ft, 1-2 Nov. 1963, C. R. Gilbert and R. Parks (field no. G 63-44).

Paratypes. UF 17279 (1 immature male, 20.5), same data as holotype; UF 16188 (1 immature female, 20.3), ANSP 109800 (1 adult female, 26.3), UMML 27335 (1 adult female, 26.4), USNM 205200 (1 adult female, 26.0), Looe Key, same general area as G 63-44, depth 15-25 ft, 6-7 August 1967, C. R. Gilbert and W. A. Starck, II (field no. G 67-46).

Diagnosis. A species of *Starksia* with a fully scaled venter; simple orbital cirrus; pores from circumorbital ossifications single (uniserial); dorsal rays XX-9 (4), XXI-8 (1), XXI-9 (1); anal rays II-18 (2), II-19 (4); pectoral rays 13-13 (6); lateral-line scales 13+1+22 (4), 14+1+21 (1), 14+1+22 (1). Distinguished from its presumed closest congener, *S. lepicoelia,* by a higher anal soft-ray count (usually 18 or 19 vs. usually 17), a higher number of total dorsal elements (usually 29 vs. usually 28), and color pattern. Color pattern consisting of eight or nine irregular, broken, widely-spaced, chocolate bars on body, which contrast strongly with a light

background; in one specimen (Fig. 1C) only the first three bars are complete and the remaining bars are replaced by a broken horizontal line. In S. *lepicoelia* pigmentation is either absent from the sides of the body or, if present, consists of broad, narrowly spaced bands that do not contrast sharply with the background.

Description. Proportional measurements appear in Table 2. Characters listed in the diagnosis are not repeated, except where clarification is required.

Pelvic rays I, 2; segmented caudal rays 13 (7+6).

Narrow simple cirri present on nape, top of eyeball, and rear margin of anterior nostril, the cirri subequal in length; teeth present on vomer and palatine bones; most or all scales of posterior part of lateral line with tubes or pores or both, the tubes uniformly present on about anterior ten scales, present only on some individual scales posteriorly; third pelvic ray not evident in unstained material; pectoral fin extending posteriorly to above base of third anal soft ray; pelvic fin reaching almost to anus.

First bar, on posterior part of head, circling nape; last bar (the hypural markings) interrupted in center, the pigment continuing, at a 90° angle, a short distance anteriorly; a large, round blotch of pigment immediately posterior to, and bordering, median section of orbit; another large blotch, slightly less intense, situated at lower posterior corner of orbit; much of opercle covered by pigment, which is, in effect, a continuation of the predorsal saddle; a small, dark humeral spot a short distance above upper part of pectoral base; a large brown blotch on lower half of pectoral base; two small blotches on extreme lower part of pectoral fin, one bordering upper margin, the other situated three-fourths to four-fifths of way down; pigment otherwise absent from most of pectoral fin, except for some melanophores outlining rays; pigment from bars on side of body encroaching a short distance onto dorsal and anal fins.

The maximum standard body length probably is less than 30 mm, based on the limited material available.

Relationships. Inasmuch as an adult male specimen of S. *starcki* is not yet available, one cannot be certain of the species' relationships. It is believed to be closest to S. *lepicoelia*, however, a premise based on the mutual presence of a completely scaled belly, general similarity in body pigmentation with some populations of S. *lepicoelia* (Böhlke and Springer, 1961, fig. 5C), and similar scale

TABLE 2

Starksia starcki: Selected measurements (expressed in thousandths of standard length) and counts

Catalogue no.	UF 10874	UF 17279	UF 16188	ANSP 109800	USNM 205200	UMML 27335
Sex	♀	♂	♀	♀	♀	♀
Std. lgth (mm)	27.3	20.5	20.3	26.3	26.0	26.4
Head lgth	311	322	305	316	312	299
Snout lgth	66	73	74	72	69	68
Upper jaw lgth	147	137	128	125	123	144
Eye diameter	81	83	84	80	88	87
Body depth	179	185	182	171	177	170
1st D spine lgth	84	88	89	76	77	87
Pectoral fin lgth	275	312	296	278	262	265
Pelvic fin lgth	201	239	227	240	235	208
Caudal fin lgth	267	268	256	251	250	258
Counts:						
Dorsal fin	XX–9	XX–9	XXI–9	XXI–8	XX–9	XX–9
Anal fin	II–19	II–19	II–19	II–18	II–18	II–19
Pectoral fin	13–13	13–13	13–13	13–13	13–13	13–13
Lateral line scales	13+1+22	13+1+22	13+1+22	14+1+22	14+1+21	13+1+22

and pectoral ray counts. Soft dorsal and anal ray counts are higher than in *S. lepicoelia* (Böhlke and Springer, 1961, Table 1), although some overlap does occur.

Ecology. All specimens of *Starksia starcki* have been taken from Looe Key, in the lower Florida Keys, in surge channels less than 25 feet deep. A total of 48 specimens of *S. ocellata* (the only other *Starksia* known from Florida) were taken in the same collections. It is remarkable that *S. starcki* has not otherwise been encountered in the numerous collections made throughout the Florida Keys. It thus is one of the relatively few Florida endemics, although one might anticipate that the species eventually will be found in Cuba.

Etymology. This species is named for Dr. Walter A. Starck, II, in recognition of his many contributions to marine biology, especially ichthyology.

DISTRIBUTION OF WESTERN ATLANTIC SPECIES

The following is a list of geographic localities from which the various western Atlantic species of *Starksia* have been recorded. For brevity's sake, authors names have been shortened as follows: Böhlke and Springer (1961) (B & S); Hildebrand, Chavez, and Compton (1964) (H, C, & C); Gilbert (1965) (G); Birdsong and Emery (1968) (B & E); Cervigon (1968) (C). All new records are based on specimens in the ANSP, UF, UMML, and USNM, except for specimens of *S. ocellata* from Panama, which are in the collection of Scripps Institution of Oceanography. Records listed by Birdsong and Emery (1968) from "off Nicaragua" are either from Courtown or Albuquerque Cays, both approximately 150 miles offshore; those from "off British Honduras" are from Turneffe Island and/or Lighthouse Reef (both within about 50 miles of shore); and those "off Yucatan" are all from Banco Chinchorro, which is a short distance off the southeastern coast. Meristic data for the Bahaman specimens of *S. hassi* follow the records for that species.

S. atlantica: B & S, Bahamas; B & E, off Nicaragua (Courtown Cays), off British Honduras (Turneffe I. and Lighthouse Reef), off Yucatan. New records: Haiti, Antigua, Old Providence I.

S. lepicoelia: B & S, Bahamas; Virgin Is.; H, C, & C, off Yucatan (Alacran Reef); G, Grand Cayman I.; B & E, off Nicaragua (Albuquerque Cays), off British Honduras (Turneffe I. and Lighthouse Reef), off Yucatan. New records: Antigua, Honduras, Old Providence I.

S. *nanodes*: B & S, Bahamas, Virgin Ids.; G, Grand Cayman I.; B & E, off Nicaragua (Albuquerque Cays), off British Honduras (Turneffe I.). New records: Haiti, Old Providence I.

S. *fasciata*: B & S, Bahamas, Cuba; G, Antigua, Dominica.

S. *sluiteri*: B & S, Old Providence I., Venezuela; G, Antigua, Dominica.

S. *y-lineata*: G, Grand Cayman I.; B & E, off Nicaragua (Courtown Cays) (erroneously listed as Yucatan by Gilbert [1969]).

S. *guttata*: B & S, Trinidad.

S. *ocellata*: B & S, North Carolina, South Carolina, Florida, Cuba, Haiti, Puerto Rico, Virgin Ids., Grenadines (Lesser Antilles), Old Providence I., Brazil, questionably from Bahamas; C, Venezuela. New record: Panama.

S. *hassi*: B & S, Netherlands Antilles (Bonaire), off Puerto Rico, off Virgin Ids.; C, Venezuela (total of eight specimens). New records: Bahamas (six localities; total of 15 specimens), off Panama (1 specimen), off Antigua (4 specimens), off Guadeloupe (1 specimen). Counts for 18 specimens listed under "new records:" Dorsal rays XIX-8 (1), XIX-9 (3), XX-8 (10), XX-9 (3), XXI-9 (1); anal rays II-16 (2), II-17 (6), II-18 (10); pectoral rays 12-13 (1), 13-13 (19), 13-14 (1), 14-13 (1); tubed anterior lateral-line scales 9 (4), 10 (9), 11 (3).

KEY TO DESCRIBED WESTERN ATLANTIC SPECIES OF *Starksia*

1. No orbital cirrus; a prominent round dark spot, about three-fourths of eye, enclosing base of last dorsal rays; genital papilla, in adult male, attached to first anal spine proximally for a distance about half its length — *Starksia atlantica* Longley

   A single orbital cirrus above each eye; round spot either absent around base of last dorsal rays or, if present, much less than three-fourths diameter of eye; genital papilla in adult male either completely free or attached to first anal spine for entire length of spine (often projecting beyond tip). (Fully developed papilla not seen in male S. *starcki*) — 2

2. A dark diagonal bar (occasionally reduced to one or two spots in small specimens) on lower part of pectoral base, well separated from proximal ends of pectoral rays; body with alternating dark and light bands, dorsal part of dark bands as wide, or wider than, light bands; venter naked; obvious pelvic rays three; apparently restricted to deep water (all records but two from 85 feet or deeper) — *Starksia hassi* Klausewitz

   No dark diagonal bar on lower part of pectoral base (bar, if present [in S. *lepicoelia*] on upper part of base, closely paralleling proximal ends of pectoral rays); body without alternating dark and light bands or, if these are present, dark band either narrower than light band (S. *fasciata* and S. *elongata*) or bands are associated with a scaled venter (S. *lepicoelia* and S. *starcki*); venter either scaled or naked; obvious pelvic rays two; not restricted to deep water (most records from less than 85 feet) — 3

3. Venter entirely and closely scaled — 4

   Venter either completely naked or with less than posterior one-third scaled — 5

4. Eight or nine irregular, widely-spaced, chocolate bands on body, these contrasting strongly with light background (in one of six specimens examined only first three bands present and a broad, incomplete, horizontal stripe extending from third band to caudal fin); anal rays II-18 (two specimens) or II-19 (four specimens); total dorsal elements 29 or 30 (XX-9 in four; XXI-8 in one; XXI-9 in one); known only from Florida (Looe Key) *Starksia starcki* new species

   Bands either absent from body or, if present, narrowly spaced and not contrasting markedly with background; anal rays usually II-17, occasionally II-18 (ca. 27 per cent of time), very rarely II-16 or II-19; total dorsal elements usually 28, occasionally 27 or 29 (29 ca. eight percent of time); generally distributed throughout Bahamas and Caribbean area, but absent from Florida *Starksia lepicoelia* Böhlke and Springer

5. A pair of hypural-shaped dark markings at base of caudal fin; arched lateral-line scales 12 to 14, usually 13; first anal spine of mature male about twice length of second spine; size smaller, maximum body length about 17 mm SL *Starksia nanodes* Böhlke and Springer

   Hypural-shaped dark markings either present (*S. elongata*) or absent; arched lateral-line scales 14 to 19, usually 15 to 18 (17 or 18 in *S. elongata*); anal spines of mature male subequal in length (except in *S. elongata*, in which first spine is nearly twice length of second); size larger, maximum body length from 20.5 to 41.5 mm SL 6

6. Pectoral rays modally 13; dorsal spines XVIII to XX (usually XIX or XX); scales in arched portion of lateral line 14 to 16, usually 15; scales in straight portion of lateral line 18 to 20, usually 19; species smaller (to 22.2 mm SL) 7

   Pectoral rays modally 14; dorsal spines XX to XXII (usually XXI); scales in arched portion of lateral line 15 to 19, usually 17 or 18 (only two specimens out of 56 with fewer than 17 scales); scales in straight portion of lateral line 20 to 23, usually 20 to 22; species larger (to 41.5 mm SL) 9

7. Color pattern consisting of seven dark bands separated by light interspaces *Starksia fasciata* (Longley)

   Color pattern not as above 8

8. Color pattern consisting of three horizontal rows of dark blotches on a light background, with the middle series rounded, the upper and lower series more square (the lowest least intense) *Starksia sluiteri* (Metzelaar)

   Color pattern consisting of a series of narrow, light, Y-shaped markings, on a dark background, on upper two-thirds of body *Starksia y-lineata* Gilbert

9. Color pattern consisting of seven well-defined, narrow, dark bars (last bar the hypural markings); body more slender and elongate; anal spine in adult male almost twice length of second spine; species probably smaller, largest observed specimen 27 mm SL *Starksia elongata* new species

   Color pattern not as above, usually consisting of dots or blotches; body less slender and elongate; anal spine in adult male slightly longer than second spine; species probably larger, reaching at least 40 mm SL 10

10. Color pattern consisting of numerous randomly distributed round black

dots, sharply defined, on lighter background; head .328-.351 in SL; upper jaw .147-.168 in SL *Starksia guttata* (Fowler)

Color pattern variable, from nearly uniform to rows of irregular and variously distinct blotches; when blotched, dark markings are much larger than in *S. guttata* and difference between blotches and background less abrupt; head .280-.314 in SL; upper jaw .133-.144 in SL *Starksia ocellata* (Steindachner)

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New Host Records for *Azygia acuminata* Goldberger 1911

Warren R. Ehrhardt and Susan S. Glenn

The trematode, *Azygia acuminata,* was originally described by Goldberger (1911), from the stomach of the bowfin, *Amia calva.* Since that time *A. acuminata* has been reported from *Amia calva* by Cooper (1915), wall-eyed pike, *Stizostedion vitreum,* white bass, *Lepibema chrysops,* and *Amia calva* by Pearse (1924), blue gill sunfish, *Lepomis macrochirus,* chain pickerel, *Esox niger,* bullheads, *Ameiurus nebulosus,* and experimentally from yellow perch, *Perca flavescens* by Wootton (1957).

The life cycle of *A. acuminata* was subsequently reported by Wootton (1957), who recovered the larval forms from a snail, *Campeloma decisum.*

The present paper reports another snail, *Campeloma geniculum* Conrad, as a new intermediate host, and the johnny darter, *Etheostoma nigrum* Rafinesque, a new host for the adult of *A. acuminata.*

Four of 4,741 specimens of *Campeloma geniculum,* collected over a twelve-month period from Little River, Wake County, North Carolina, were found infected with larval forms of *A. acuminata.* Infected snails occurred only during the winter months (November, December, January, and February).

All snails were placed in well-aerated finger bowls containing pond water and observed for emergence of cercariae. Cercariae were actively shed from only two snails. Emergence occurred by the fifth day and continued until the forty-fifth day, usually between the hours of 9-12 PM. Both infected snails died by the sixty-fifth day. A total of 133 cercariae were collected from one snail and 148 from the second.

All snails collected were observed in the laboratory for at least two weeks, then crushed and examined for infection. Larval forms of *A. acuminata* were recovered from two snails by this method. Although rediae in various stages of development were recovered from the gonadal tissue of the latter two snails, cercariae were never shed.

Developmental Stages

Miracidium and sporocyst stages were not observed. Examination of the four infected snails revealed the presence of 51, 38, 42,

and 57 rediae in various stages of development in the gonads of the snail.

The smallest redial stage observed was 0.58-0.98 (0.77) long by 0.38-0.73 (0.53) wide, cream-colored, oval-shaped, entirely annulated, containing germinal balls. A terminal birth pore opens to the exterior at the anterior end.

Developing cercariae were present in rediae 1.40-1.95 (1.69) long by 0.58-0.85 (0.68) wide. As the redia increases in length, the annular appearance disappears. The largest rediae, 3.40-5.50 (4.00) long by 0.65-0.85 (0.75) wide, were thin-walled and contained from 12-20 well developed cercariae with the distome attached outside the tail stem.

Developing cercariae appear as small oblong bodies, 0.12-0.122 long by 0.6-0.7 wide, containing undifferentiated cells. As differentiation proceeds a dense accumulation of cells occurs at the posterior end of the body. A constriction develops in this region from which the tail stem forms. This is followed by an elongation of the anterior end of the body with the early formation of the oral sucker. Acetabular and intestinal ceca primordia are present. The distome body develops more rapidly than the tail stem, with the furci showing the least development. Distomes within the redia remain unencysted and are attached to the inner wall of the tail stem by two bands of muscle tissue which arise immediately posterior to each of the intestinal ceca. This muscular attachment appears to be a means of retraction of the distome into the tail cavity. The excretory bladder of the distome is contiguous with the main excretory canal of the tail stem. Once the distome becomes encysted within the tail this excretory connection is lost, and the distome comes to lie free within the cavity. Actual encystment of the distome was not observed by these authors but has been described by Wootton (1957).

DESCRIPTION OF CERCARIA

Furcocystocercous; unpigmented except for yellow-colored distome encysted in the anterior seventh of the tail stem. Tail stem club-shaped, tapering slightly toward furci. Spines and mammillations absent. Length 2.55-3.33 (2.96), width 0.65-0.83 (0.77). Opening to tail stem cavity terminal and surrounded by a large

number of prominent papillae. Anterior third of tail stem weakly muscular, posterior two-thirds strongly muscular. Furca slightly wider than long; length 0.60-0.88 (0.80), width 0.80-1.03 (0.85), weakly muscular; small scale-like projections symmetrically arranged along the outer margins. Main excretory canal medial, extending from the distome cavity to the posterior end of the tail stem, where it bifurcates with a branch passing into each furci and opening to the exterior along the posterior medial border. Secondary excretory tubules and flame cell arrangement in tail stem are similar to those described by Wootton (1957). Distome; muscular with thick cuticle and mammillations extending to the anterior level of the acetabulum. Body length 0.45-0.60 (0.53), width 0.33-0.38 (0.35). Acetabulum muscular; anterior lip mammillated; diameter 0.18-0.20 (0.19), located in middle third of the body, 0.24-0.30 (0.29) from the anterior end. Oral sucker, subterminal, muscular with mammillations on anterior lip; length 0.15-0.20 (0.18), width 0.17-0.19 (0.18). Ratio of oral sucker to ventral sucker approximately 1:1. Pre-pharynx absent. Pharynx, muscular, 0.07-0.08 (0.075) long by 0.05-0.07 (0.06) wide. Intestinal cecum thick-walled, convoluted, containing refractile granules, extending to near posterior end of body. Genitalia immature; testes intracecal, oblique, located near posterior end of body. Ovary lobate, anterior and medial to testes. Uterus medial passing anteriorly dorsal to acetabulum, opening to genital atrium located immediately anterior to acetabulum. Eggs absent. Vitellaria undeveloped. Excretory bladder posterior to testes. Excretory tubules pass anteriorly medial to testes and extend to region of oral sucker. Flame cell arrangement not determined. (All measurements are in millimeters).

FISH EXAMINATIONS

Two hundred fish of the families Ictaluridae, Centrachidae, and Percidae, all common in Little River, were examined for the presence of the adult of *A. acuminata*. All except the johnny darters were found negative for this parasite. One adult worm was recovered from the stomach of each of the two infected fish. The morphological characters and measurements closely agree with the description of Goldberger (1911) and Wootton (1957).

Summary

The recovery of the larval forms of *Azygia acuminata,* from the gonads of the snail, *Campeloma geniculum* Conrad, and adults from the stomach of the johnny darter, *Etheostoma nigrum,* are new host records, and North Carolina represents a new locality record for this parasite.

Developmental stages of the redia and cercaria are described. Morphological characters and measurements closely agree with those of Wootton (1957).

All ictalurids, centrachids, and perch that were examined from Little River for the adult of *A. acuminata,* were found negative with the exception of two johnny darters, *Etheostoma nigrum,* from the stomach of each of which a single adult worm was recovered.

Acknowledgments

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Live Shipping of Florida's Spiny Lobster

Ross Witham

Florida's spiny lobster, *Panulirus argus*, is ordinarily cooked, packaged, and frozen before shipment. The consumer, who must thaw and reheat the lobster, often serves an overcooked product of reduced quality. Live shipment of spiny lobsters can increase consumer acceptance by enhancing the product's appearance and palatability.

Large quantities of northern lobster, *Homarus americanus*, are shipped alive under cool, moist conditions (Anon., 1948). Live African rock lobsters, *Jasus lalandei*, are air shipped from South Africa to Europe (Harvey, 1962). Harvey reports 100 per cent survival for 24 hours and about 50 per cent survival after 44 hours when the temperature inside of the carton had been lowered to 3.9 C (39 F) and allowed to warm gradually to ambient air temperature of 18.9 C (66 F). These procedures have been extremely successful and provide a product of highest quality. Other aquatic animals, including fishes and shrimp for aquaria and shrimp for food are shipped alive (Idyll, 1965; Futch and Woodburn, 1967). Barnett et al. (1969) report success in air shipment of live dungeness crabs, *Cancer magister*, with reduced temperatures, 1.7 C (35 F) to 10.0 C (50 F), and relative humidity of 80-100 per cent. Increased costs of handling are usually offset by an increased demand and a higher retail price. Consequently, the Marine Laboratory initiated these studies to determine the best conditions for shipping live Florida lobsters.

Methods and Materials

Packing Material Tests. The first experiment was designed to test the effectiveness of various materials under different temperature conditions. Adult lobsters were obtained from commercial sources and maintained for at least one day to ascertain their good health. A dozen live lobsters were then packaged four to a shipping carton, using seawater-wetted burlap bags. Another dozen were packed in seawater-wetted sargassum weed, and a third dozen in seawater-wetted polyurethane foam. A fourth dozen,

similarly handled but with no packing material, served as a control. Cartons packed under each method were held at 4.4 C (40 F), 10.0 C (50 F), and at ambient temperature. The animals were examined twice daily for three days (Table 1). The experiments were replicated to verify results (Table 2). A third series of packing tests, using burlap at ambient temperature, were carried out on groups of 10, 12, and 18 lobsters for 36 hours (Table 3).

Shipment in water-filled plastic-lined cartons is considered inadvisable because of prohibitive shipping costs, as well as the danger of puncture and subsequent water loss. Although Idyll (1965) reported successful shipping of live shrimp in sawdust, this method was not tested because a suitable supply was not available.

Spray Unit Tests. Previous experiments using a seawater spray over live lobsters had indicated the possibility of prolonging survival and therefore a small self-contained, portable spray system was tested. Such a unit was placed in the back of a pickup truck (Fig. 1). The spray tank (4′×2′×16" deep) contained eight lobster holding trays (16"×16"×4" deep) and was covered by a lid designed to allow air to circulate while at the same time retaining the saltwater spray. The tank and trays were made to hold approximately 3/4" of seawater, since it had been observed previously that the lobsters died unless some water was retained in the trays. Because ultraviolet light effectively sterilizes water (Anon., 1965; Nagy, 1965; Torpey et al., 1966) a sterilizing tank was constructed using two 30-watt ultraviolet tubes, and was located between the spray tank and a water storage tank. Seawater was pumped by a "Teel" 115 volt recirculating pump, Model 1P618, through a filter made of plastic pipe packed with 20 mesh per inch nylon webbing. All pipe and the small spray heads were nontoxic plastic. After spraying into the holding tank, the water returned by gravity through the sterilization chamber to the storage tank. While on the truck electricity for the pump and ultraviolet lights was provided by a "Topaz Powermaker," Model 310-B-12, which converted the 12 volt DC to the necessary 115 volt AC.

The first survival experiment was conducted with the portable spray unit assembled in the air-conditioned laboratory, where temperatures ranged from a low of 24.4 C (76 F) to a high of 31.1 C (88 F). Forty subadult lobsters, 34 that had been in a tank at the House of Refuge Museum for a month or more and six that had

TABLE 1

Number of lobsters surviving in various packing media and selected temperatures. (Packing Test No. 1)

Date	2-23-67	2-23-67	2-24-67	2-24-67	2-25-67	2-25-67	2-26-67
Time of check	9:00 AM	4:00 PM	8:00 AM	4:00 PM	9:00 AM	5:00 PM	7:30 AM
Hours (rounded)		7	23	31	48	56	71
4.4 C (40 F)							
No packing	4	0					
Burlap	4	0					
Polyurethane foam	4	4	0				
Sargassum	4	4	0				
10.0 C (50 F)							
No packing	4	3	2	0			
Burlap	4	4	2	2	2	1	1
Polyurethane foam	4	4	4	4	1	2	1
Sargassum	4	4	4	4	4	4	3
7.2 C (45 F)—21.1 C (70 F ambient temp.)							
No packing	4	4	4	3	1	1	0
Burlap	4	4	4	4	4	4	4
Polyurethane foam	4	4	4	4	4	3	2
Sargassum	4	4	4	4	3	2	1

TABLE 2

Number of lobsters surviving in various packing media and selected temperatures. (Packing Test No. 2)

Date	3-10-67	3-16-67	3-17-67	3-17-67	3-18-67	3-18-67
Time of Check	10:00 AM	4:00 PM	8:45 AM	4:00 PM	8:30 AM	4:30 PM
Hours (rounded)		6	23	30	47	55
4.4 C (40 F)						
No packing	4	0				
Burlap	4	1	1	0		
Polyurethane foam	4	2	0			
Sargassum	3	3	3	1	0	
10.0 C (50 F)						
No packing	4	3	2	1	0	
Burlap	4	4	1	1	0	
Polyurethane foam	4	4	3	3	1	0
Sargassum	4	4	2	1	0	
18.3 C (65 F)—29.4 C (85 F ambient temp.)						
No packing	4	4	2	0		
Burlap	4	4	3	3	0	
Polyurethane foam	4	2	2	2	1	0
Sargassum	4	4	4	4	2	0

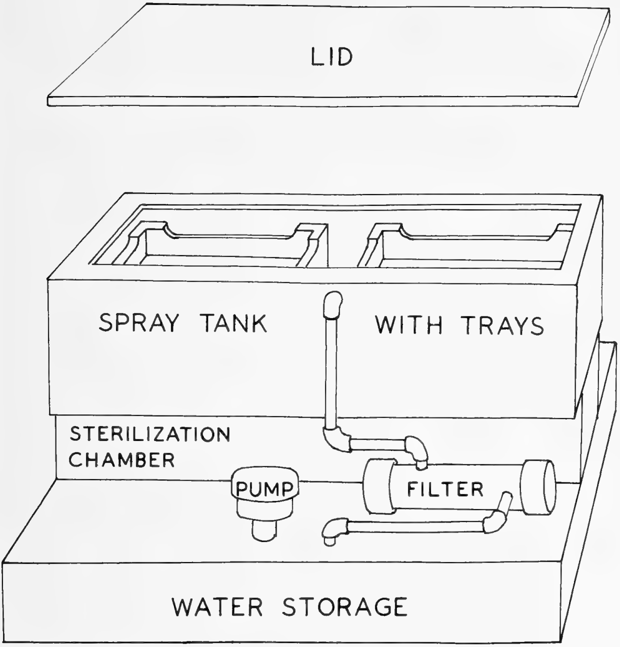

Fig. 1. Portable spray unit.

been newly caught in the Indian River north of the St. Lucie Inlet, served as test animals. In the second test, 40 adult lobsters were obtained from commercial sources at Key Largo, Florida. The spray unit was installed on the pickup truck and temperatures were not controlled, ranging between 15.6 C (60 F) and 22.2 C (72 F). In both tests the unit was checked twice daily and dead lobsters were removed.

RESULTS AND DISCUSSION

Packing Material Results. In the first test (Table 1), all lobsters held at 4.4 C (40 F) were dead within 23 hours. Those held

TABLE 3

Number of lobsters surviving in burlap packing at ambient temperatures. (Packing Test Nos. 3, 4, & 5)

	Date	4-19-67	4-20-67	4-21-67	
	Time of check	8:00 PM	4:00 PM	8:00 AM	
	Hours (rounded)		20	36	
#3	21.7 C (71 F)- 28.3 C (83 F)	10	10	3	
	Date	8-22-67	8-23-67	8-24-67	
	Time of check	8:00 PM	5:00 PM	8:00 AM	
	Hours (rounded)		21	36	
#4	18.3 C (65 F)- 23.9 C (75 F)	12	12	11	
	Date	9-20-67	9-21-67	9-21-67	9-22-67
	Time of check	Noon	8:00 AM	4:30 PM	8:00 AM
	Hours (rounded)		20	29	44
#5	17.8 C (64 F)- 24.4 C (76 F)	18	12	7	3

at this temperature but with no packing or with burlap packing were dead within 7 hours.

The 10.0 C (50 F) temperature gave somewhat better survival. Two of the 4 lobsters with no packing and 2 with burlap packing lived over 23 hours. The 4 lobsters with no packing were dead within 31 hours, while 2 of those in burlap survived for 48 hours and one was still alive after 3 days. Polyurethane foam yielded 100 per cent survival through 31 hours, but only one lived until the end of the test. All 4 lobsters packed in sargassum lived for 56 hours and 3 were alive after 3 days.

The best results were obtained at temperatures between, 7.2 C (45 F) through 21.1 C (70 F). At these temperatures, all of those in the containers with no packing material lived for 23 hours, and 3 survived 31 hours. Only one was alive after 56 hours and none survived the test. All of those packed in burlap lived throughout the experiment. Polyurethane foam packing yielded 100 per cent survival for 48 hours, 75 per cent for 56 hours and 50 per cent were still alive when the test terminated. In sargassum weed packing, all 4 lobsters lived through 31 hours, 3 through 48 hours, 2 for 56

hours, and one survived the test. Results of the first test are given in Table 1.

During the second test (Table 2) survival was again poorest at 4.4 C (40 F). Lobsters with no packing were all dead within 6 hours. Three of the 4 in burlap were dead within 6 hours and the remaining one died sometime after the 23rd hour. In polyurethane foam, 50 per cent survived 6 hours but all were dead by the end of 23 hours. Of the 3 test lobsters packed in sargassum, all survived for 23 hours and one for 30 hours.

Once again, survival at 10.0 C (50 F) exceeded that at 4.4 C (40 F). Three of the 4 lobsters with no packing lived 6 hours, 2 were alive after 23 hours, and one after 30 hours, but all were dead by 47 hours. In burlap packing, 100 per cent lived through 6 hours but only one lived through 30 hours and it was dead by 47 hours. Those in polyurethane, as well as those in sargassum, lived for 6 hours, 3 of those in polyurethane and 2 of those in sargassum were alive for 30 hours, and one in polyurethane lived through 47 hours. None in the sargassum lived for 47 hours.

Survival at room temperature, 18.3 C (65 F) through 29.4 C (85 F), was once again better than at low temperatures. All lobsters with no packing survived 6 hours, 2 for 23 hours, and all were dead by 30 hours. All those in burlap packing lived through 6 hours and 3 survived for 30 hours. Only 50 per cent of those in polyurethane lived 6 hours but these remained alive for 30 hours, and one was alive after 47 hours. In sargassum packing, all 4 survived 30 hours and 2 for 47 hours, but none survived 55 hours.

The favorable results obtained with burlap packing at room temperatures prompted 3 more trials using this method, but the lobsters were to be held only 36 hours. The erratic results of these three tests do not appear dependent on temperature variations (Table 3). With temperatures of 21.7 C (71 F) through 28.3 C (83 F) the 10 lobsters lived for 20 hours but only 3 survived for 36 hours. When the temperatures were 18.3 C (65 F) through 23.9 C (75 F), all 12 lobsters lived for 21 hours and 11 survived until the test terminated at 36 hours. At temperatures of 17.8 C (64 F) through 24.4 C (76 F) 12 of the 18 lived for 20 hours, 7 for 28 hours, and 3 were still alive at the final checking.

Spray Unit Results. During the first experiment with the portable spray unit in the laboratory, where temperatures were from

24.4 C (76 F)-31.1 C (88 F), all 40 lobsters lived 17 hours but 3 (7.5 per cent) had died by the end of 24 hours. After 65 hours an additional 2 (5 per cent) had died. By the end of the third day (72 hours) another one (2.5 per cent) was dead and one (2.5 per cent) more was dead after 89 hours. No more died until the beginning of the sixth day, by which time 2 (5 per cent) more were dead. The remaining 31 lived through the experiment, giving a survival rate of 77.5 per cent for 7 days. Three of the 9 dead lobsters were found in the process of molting and this may have affected their survival.

In the second test, 15.6 C (60 F)-22.2 C (72 F), with the spray unit installed on the pickup truck, 4 (10 per cent) were dead at 24 hours, with 3 (7.5 per cent) having failed to live for 15 hours. An additional 2 (5 per cent) died before the end of 48 hours. The greatest mortality 9 (22.5 per cent) occurred between 48 and 63 hours. Following the 72nd hour and before the 87th hour, another 6 (15 per cent) died. Four others (10 per cent) died during the time between 96 and 111 hours. Another 3 (7.5 per cent) were dead before the end of the fifth day (120 hours). At the start of the seventh day, one (2.5 per cent) more was dead and the remaining 10 (25 per cent) lived for the full 7 days (168 hours). The results of the two tests with the portable spray unit are given in Table 4.

Summary

Polyurethane foam, sargassum, and burlap bags were wetted with seawater and tested as packing material for live Florida spiny lobsters under varying temperature conditions. Lobster survival in each of these materials was compared with survival of control lobsters held without packing materials. Seawater-wetted burlap bag packing at room temperature gave the best results. Average survival in five tests was approximately 85 per cent for 20-23 hours and 58 per cent for 29-36 hours. Consequently, shipment of live, healthy lobsters under these conditions appears feasible if delivery can be assured within 24 hours and temperature extremes can be avoided.

A system using filtered, sterilized seawater sprayed over live lobsters gave good survival for a minimum of two days and in one experiment 77.5 per cent of the lobsters were in good condition

TABLE 4

Number of lobsters surviving in a self-contained, portable spray unit

	Test No. 1, with unit in an air-conditioned laboratory							
Date	5-31-68	6-1-68	6-2-68	6-3-68	6-4-68	6-5-68	6-6-68	6-7-68
Time of check	3:00 PM	3:30 PM	3:30 PM	3:30 PM	3:00 PM	4:30 PM	3:30 PM	3:00 PM
Hours (rounded)		25	49	73	96	122	145	168
24.4 C (76 F)— 31.1 C (88 F)	40	37	37	34	33	33	31	31
	Test No. 2, with unit in pick-up truck							
Date	1-20-69	1-21-69	1-22-69	1-23-69	1-24-69	1-25-69	1-26-69	1-27-69
Time of check	5:00 PM	5:00 PM	5:00 PM	5:00 PM	5:00 PM	5:00 PM	5:00 PM	5:00 PM
Hours (rounded)		24	48	72	96	120	144	168
15.6 C (60 F)— 22.2 C (72 F)	40	36	34	24	18	11	11	10

after one week. This method appears to have possibilities for holding and surface shipment of Florida lobsters.

ACKNOWLEDGMENTS

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Subspecific Variation in Two Species of Antillean Birds

Albert Schwartz

Collections of birds made between 1959 and 1968 in the West Indies have been reported upon in three recent papers (Schwartz and Klinikowski, 1963; Schwartz and Klinikowski, 1965; Paulson, 1966). Detailed study of portions of these collections reveals that the status of the populations of *Columbina passerina* (Linnaeus) on Cuba (and the Isla de Pinos) and *Geothlypis rostrata* Bryant on Cat and Andros islands in the Bahamas requires clarification. The purpose of the present paper is to discuss the variation in these two species as it is applicable to the populations in question. In addition to the specimens in my collection (herein designated AS), I have examined pertinent material in the collections of the Academy of Natural Sciences of Philadelphia (ANSP), the American Museum of Natural History (AMNH), the Field Museum of Natural History (FMNH), the Museum of Zoology, Louisiana State University (LSUMZ), and the United States National Museum (USNM). For the loan of these specimens I gratefully acknowledge the assistance and cooperation of James Bond, Wesley E. Lanyon, Emmet R. Blake, George H. Lowery, Jr., and George E. Watson.

All measurements are in millimeters and were taken from museum skins with vernier calipers by Donald W. Buden, to whom I am very grateful. Field measurement, also in millimeters, of total length, tail, wing arc and exposed culmen, taken from the bird while still in the flesh prior to skinning, have also been employed. Color designations are from Maerz and Paul (1950). I wish to acknowledge the assistance of William B. Robertson, Jr., in obtaining literature, and the capable assistance rendered me in the field by several students. Cuban collections were made with the assistance of National Science Foundation grants G-3865 and G-6252 to the author.

Columbina passerina (Linnaeus)

Bond (1956) accepted nine resident subspecies of *Columbina passerina* in the Antilles; the species is widespread throughout the islands, occurring on the Bahama Islands in the north, on all the

Greater Antilles (including Navassa and Mona islands), and south through the Lesser Antilles to Grenada. Of the nine subspecies which are found on the islands, *C. p. insularis* Ridgway has the broadest distribution as far as major land masses is concerned; this subspecies, described from specimens collected on Grand Cayman Island, occurs in Cuba, the Isla de Pinos, the Cayman Islands, Hispaniola (including the satellite islands of Gonâve, Tortue, Saona, Catalina, Ile-à-Vache) and Navassa Island (whence *C. p. navassae* Wetmore has been named; *navassae* is currently in the synonymy of *insularis*).

Collections made by myself and parties between 1957 and 1960 in Cuba include ground doves from various localities on that island. When these skins are compared, even superficially, with specimens collected in the Cayman Islands and Hispaniola in the years immediately following (and thus also fresh skins), it is obvious that birds from these latter islands are quite distinct from those from Cuba. Todd (1913, pp. 561-564) considered Cuban, Isla de Pinos, and Hispaniolan ground doves as *C. p. aflavida* (Palmer and Riley) and restricted *insularis* to the three Cayman Islands. Ridgway (1916, p. 415) likewise considered the Cuban and Isla de Pinos birds as *C. p. aflavida* and did not separate these populations from those from Hispaniola which he also regarded as *aflavida*. Todd (1916, p. 222) later regarded the Isla de Pinos birds as *aflavida* but made no comparisons of that subspecies with *insularis*. Hellmayr and Conover (1942, pp. 528-529) considered *aflavida* a synonym of *insularis* and stated that Bangs (1916, p. 307) had pointed out that Cuban birds were inseparable from topotypical *insularis*. Remarkably, of 99 *C. p. insularis* examined by Hellmayr and Conover (p. 529) only one was from Cuba (from San Diego de los Baños in Pinar del Río Province), whereas they studied 29 Caymanian and 69 Hispaniolan birds. Thus their comments on the identity of Cuban and Caymanian *Columbina* appear to have been based exclusively on Bangs' research.

I have examined 20 specimens from Cuba, 19 from the Cayman Islands, 14 from Hispaniola, and two from Navassa, as well as six birds from Jamaica (*jamaicensis* Maynard), 14 from the Bahama Islands (*bahamensis* [Maynard]), and four from southern Florida (*passerina* [Linnaeus]). I have also had available skins of the re-

maining Antillean subspecies, none of which is pertinent to the present problem.

Inspection of Tables 1 and 2 shows the following. Turning first to the field-taken measurements (total length, tail, wing arc), the Cuban males have the highest extremes in all measurements in

TABLE 1

Means and extremes (in millimeters) of six populations of *Columbina passerina*; all measurements taken in the flesh. See list of specimens examined for localities involved. No female Hispaniolan *insularis* studied had field taken measurements.

	N	Sex	Total length	Tail	Wing arc
aflavida	7	M	168.6 (161-179)	58.1 (55-64)	88.7 (85-94)
	1	F	171	59	89
insularis	4	M	162.0 (160-166)	56.3 (50-59)	86.0 (84-89)
(Cayman Islands)	2	F	151.5 (150-153)	56.5 (56-57)	82.5 (82-83)
insularis (Hispaniola)	3	M	169.3 (168-170)	60.0 (58-62)	87.0 (86-88)
jamaicensis	2	M	160.5 (158-163)	56.0 (55-57)	85.5 (85-86)
	4	F	160.2 (157-162)	56.5 (54-60)	84.0 (83-85)
bahamensis	7	M	162.6 (156-168)	56.7 (54-60)	85.6 (84-88)
	11	F	159.4 (150-167)	57.6 (53-63)	84.9 (82-91)
passerina	3	M	171.3 (170-174)	61.7 (58-64)	94.3 (93-95)
	1	F	150	62	90

comparison with other adjacent Antillean populations and are exceeded in total length and wing arc only by mainland *C. p. passerina.* Although the data are far less satisfactory for Cuban females, the total length of the single Cuban female is not included within the extremes of any West Indian females, nor does this measurement fall within the extremes of any population of *insularis.* The Cuban female wing arc likewise falls outside the upper limit of all *insularis* females but lies within the known range of female *bahamensis* and *passerina.*

Of the laboratory taken measurements, mean tail length in Cuban males is 61.9, of Cuban females 60.3. Of the Antillean populations, means of male tail length average from 56.1 (Hispaniolan *insularis*) to 58.7 (*bahamensis*). Even mainland *passerina* has a lower mean tail length (59.5) than do Cuban males. The tail length of Cuban females shows the same situation, with the Cuban

TABLE 2

Means and extremes (in millimeters) of six populations of *Columbina passerina*; all measurements are laboratory taken. Bill measurement equals chord from anterior border of naris to tip.

	N	Sex	Tail	Wing Chord	Bill	Tarsus
aflavida	13	M	61.9 (57.0-64.7)	83.2 (78.1-87.5)	11.6 (10.4-12.3)	14.7 (13.7-16.0)
	7	F	60.3 (59.2-61.4)	82.8 (82.0-86.5)	11.6 (10.9-12.2)	15.2 (14.4-15.8)
insularis (Cayman Islands)	10	M	57.0 (55.2-60.0)	82.9 (80.0-85.8)	10.9 (10.3-12.1)	14.7 (14.1-15.6)
	6	F	55.8 (55.0-57.9)	80.7 (79.8-82.7)	10.6 (10.1-10.9)	14.5 (14.3-14.7)
insularis (Hispaniola)	8	M	56.1 (51.3-59.5)	82.5 (80.3-85.6)	11.5 (11.0-12.2)	14.6 (14.1-14.9)
	4	F	54.2 (53.1-56.0)	81.0 (79.5-81.6)	11.3 (11.2-11.4)	14.3 (14.3-14.4)
jamaicensis	2	M	57.6 (57.3-57.9)	82.0 (81.7-82.3)	11.9 (11.4-12.3)	13.8 (13.1-14.5)
	4	F	55.6 (54.0-56.7)	79.8 (78.6-81.5)	12.0 (11.7-12.3)	14.7 (14.5-14.8)
bahamensis	6	M	58.7 (54.5-62.5)	82.4 (78.2-85.6)	11.1 (10.7-11.8)	14.7 (14.1-15.3)
	11	F	56.3 (53.9-58.8)	78.4 (76.7-83.5)	11.0 (10.0-11.4)	14.4 (14.0-15.0)
passerina	3	M	59.5 (59.2-59.7)	88.3 (87.2-89.1)	11.8 (11.5-12.0)	15.8 (15.5-16.0)
	1	F	58.7	85.7	10.3	15.8

females having a mean of 60.3 with means of 55.8 in Caymanian *insularis,* 54.2 in Hispaniolan *insularis,* 55.6 in *jamaicensis,* and 56.3 in *bahamensis.* In both sexes, despite overlap, the upper extremes of tail length of Cuban birds lie beyond those for all other populations studied.

In measurements of wing chord, the male Cuban mean of 83.2 is greater than the means of all other Antillean samples (means 82.0-82.9) and is exceeded only by continental *passerina.* Wing chord in Cuban females likewise is greater (82.8) than in the other Antillean samples (means 78.4-81.0, the highest mean that of Hispaniolan *insularis*), but the single female *passerina* has a wing chord of 85.7. Bill measurements (tip of bill to anterior margin of naris) of Cuban males and females have higher means (11.6 in both sexes) than all other West Indian populations, with the exception that male *jamaicensis* average 11.9 and female *jamaicensis* 12.0 in this measurement. The tarsus measurements of Cuban males (mean 14.7) is equal to that of Caymanian and Hispaniolan *insularis* and *bahamensis,* but exceeds the mean of male *jamaicensis* (13.8). The tarsus mean of Cuban females (15.2) is greater than that of all other Antillean females (means 14.3-14.7).

The above comments and Tables 1 and 2 indicate clearly that the Cuban population of *C. passerina* differs quite strongly in mensural characters, not only from the subspecies *jamaicensis* and *bahamensis,* but also from those populations with which it has been previously associated as *C. p. insularis.* In size, the Cuban birds are more or less intermediate between the continental *passerina* on one hand and the remainder of the western Antillean subspecies on the other. The overall size difference between Cuban *aflavida* and the remaining West Indian forms is quite obvious when skins of these four subspecies are even grossly compared.

Comparisons of male *passerina, aflavida, insularis, jamaicensis* and *bahamensis* as far as depth of pigmentation is concerned shows the following. Males of each subspecies are variable among themselves, but there are very definite trends toward depth of color, both dorsally and ventrally, which are obvious when series are compared. Ranked by darkness of ventral color, the races stand as *jamaicensis, passerina, aflavida, insularis,* and *bahamensis,* with *jamaicensis* being the darkest subspecies and *bahamensis* the palest. Male *jamaicensis* are deep vinaceous below (Pl. 54 D 1; Maerz

and Paul, 1950), with *passerina* males only slightly paler (Pl. 54 C 3). *C. p. aflavida* is still paler than the nominate subspecies, typical colors being Pl. 54 B 4 and Pl. 54 A 5. Caymanian *insularis* average distinctly paler than *aflavida* (Pl. 53 B 3) and even the darkest Caymanian males (Pl. 45 F 1) are paler and less purplish (more brown) than *aflavida*. Hispaniolan *insularis* agree closely with topotypical specimens of that subspecies, although there is a tendency for Hispaniolan birds to be slightly darker (more red) than Caymanian *insularis*. Male *bahamensis* are the palest ventrally, with a somewhat grayer tone (Pl. 53 A 2).

Ranking males by the depth of the dorsal plumage color yields a series of *aflavida, passerina, jamaicensis, bahamensis,* and *insularis*. Note that of this series, *aflavida* and *insularis* stand at opposite extremes. Typical *aflavida* colors are Pl. 15 E 9 and Pl. 15 C 4, whereas topotypical *insularis* dorsa include Pl. 14 A 3 and Pl. 14 B 4. Occasional Caymanian *insularis* (USNM 316752, for instance) resemble occasional *aflavida* (USNM 453536), but the series are quite easily separable on the basis of the darker (more brown) coloration of male *aflavida* and the paler (more gray) backs of *insularis*. There is no mean difference in the depth of the gray crown and squamate nape feathers nor of the tan loreal feathers, although I have the impression that very generally the latter are more reddish in *aflavida* than in Caymanian *insularis* and are even more deeply reddish in Hispaniolan *insularis*.

Females of the four subspecies are similar in many respects. Ventrally, female *bahamensis* have the central portion of the belly most clearly white and have the chest most distinctly squamate, the feathers with the palest buffy edges, of the populations in question. Female *aflavida* are slightly grayer ventrally and have the central portion of the belly more buffy than do female *insularis*, whereas female *jamaicensis* are the darkest (most gray-brown) of the subspecies. As far as dorsal coloration is concerned, female *jamaicensis* are the darkest (Pl. 15 G 5) and *bahamensis* the palest (Pl. 14 A 2). Female *aflavida* are a rich brown (Pl. 15 E 9) whereas female Caymanian *insularis* are paler (Pl. 15 A 7). There is a distinct tendency for the crown and squamate nape feathers to have paler centers (and thus more prominent dark edges) in *aflavida* than in *insularis*.

Two freshly collected (1965) specimens in unworn plumage from Navassa Island (which presumably might be separable from *insularis* as *C. p. navassae*) do not differ in size nor pigmentation from recently collected Hispaniolan *insularis*. There seems no reason to resurrect *navassae* from the synonymy of *insularis*.

In summary, it is appropriate to consider *C. p. aflavida* Ridgway a valid subspecies occurring on Cuba (and presumably on the Isla de Pinos whence I have seen no material). In size and in depth of pigmentation, *aflavida* meets all the criteria for a recognizable subspecies of *Columbina passerina*.

I disagree with Hellmayr and Conover (1942, p. 530, footnote 2) that *bahamensis* is "a very unsatisfactory race." Although *bahamensis* resembles *insularis* (*sensu stricto*) in its small size, its distinctly paler coloration, both dorsally and ventrally and in both sexes, reassures me of its distinctness from other adjacent subspecies.

I have, in the foregoing discussion, made no mention of the presence of, or the amount of (if present), red on the bill of the various populations. There are no color data on any of the material at hand as far as this character is concerned. However, judging by the presently pale areas on the culmens I imagine that the Cuban populations lack this feature (for which reason the name *aflavida* was proposed), and that *insularis* has some basal portions of the bill red.

Specimens examined: *C. p. aflavida*: *Cuba*, Pinar del Río Prov., San Vicente, 2 (AS); Habana Prov., Boca de Jaruco, 3 (AS); Camagüey Prov., 6 mi. S Playa Santa Lucía, 1 (AS); Oriente Prov., 4 mi. E Gibara, 1 (USNM); Santiago de Cuba, 2 (USNM); 23 km E Siboney, 1 (AS); 4 mi. W Baitiquirí, 1 (AS); vicinity of Guantánamo, 9 (USNM).

C. p. insularis: *Haiti*, Dépt. du Sud, Jérémie, 1 (USNM); Dépt. de l'Ouest, L'Arcahaie, 1 (USNM); 1.1 mi. S. Mirebalais, 1 (AS); Dépt. du Nord, Port-de-Paix, 1 (ANSP); Ile de la Gonâve, Anse à Galet, 2 (ANSP, USNM); Etroits, 1 (USNM); Ile de la Tortue, 1 (USNM); *República Dominicana*, Distrito Nacional, Santo Domingo, 3 (ANSP); La Romana Prov., Isla Catalina, 1 (AS); San Juan Prov., 15 km SE San Juan, 1 (AS); *Cayman Islands*, Grand Cayman, no further locality, 10 (ANSP, USNM); 3 mi. N Georgetown, 1 (AS); 3.5 mi. N East End, 3 (AS); 5.7 mi. ENE, 0.5 mi. N Bodden Town, 1 (AS); Little Cayman, Blossom Point, 1 (AS); Navassa Island, between Lulu Bay and lighthouse, 2 (AS).

C. p. jamaicensis: *Jamaica*, St. Ann Parish, 1 mi. E Discovery Bay, 2

(AS); St. Catherine Parish, Fort Clarence, 1 (AS); Manchester Parish, 0.7 mi. W Gut River, 2 (AS); 0.9 mi. W Gut River, 1 (AS).

C. p. bahamensis: *Bahama Islands,* Grand Bahama, Bootle Bay, 3.5 mi. E West End, 1 (AS); 45 mi. E Freeport, 1 (AS); 3.4 mi. W High Rock, 1 (AS); Great Abaco, 8 mi. WNW Treasure Cay, 1 (AS); Andros, 2 mi. S Fresh Creek, 2 (AS); New Providence, 3.8 mi. W Oakes Field, 1 (AS); Eleuthera, Hatchet Bay Plantation, 5 (AS); Cat, 3.2 mi. E Old Bight, 1 (AS); San Salvador, 2 mi. NNE Cockburn Town, 1 (AS); 6.9 mi. NE Cockburn Town, 3 (AS); 7.1 mi. N Cockburn Town, 1 (AS).

C. p. passerina: Florida, Dade Co., 4 mi. W South Miami, 1 (AS); 1 mi. N North Miami P.O., 1 (AS); Monroe Co., Sugarloaf Key, 1 (AS); Boca Chica Key, 1 (AS).

Geothlypis rostrata Bryant

The Bahama Yellowthroat (*Geothlypis rostrata*) has long been known as an endemic resident on the Bahama Islands of Grand Bahama and Great Abaco (including many offshore cays), New Providence, Andros, and Eleuthera. Paulson (1966, p. 10) first reported the species from Cat Island, to the south of Eleuthera. The nomenclatural history of the various insular populations of *G. rostrata* is extremely complex. Ridgway (1902, p. 674 et seq.) recognized seven Bahamian species, three of which occurred on New Providence, two on Abaco, one on Andros, and one on Eleuthera. This most peculiar situation was later clarified by Todd (1911) who, after careful comparison and analysis of plumages, relegated Ridgway's seven species to one species with three subspecies: the nominate subspecies on New Providence and Andros, *G. r. tanneri* Ridgway on Grand Bahama and Abaco, and *G. r. coryi* Ridgway on Eleuthera. This arrangement of forms has been followed by Hellmayr (1935), although he made some comments on the still confused situation and had only limited material from several islands whence *G. rostrata* had been reported. The current Antillean checklist (Bond, 1956) likewise follows Todd's arrangement. Paulson tentatively regarded his Cat Island specimens as *G. r. coryi,* since they did not agree with specimens of nominate *rostrata* or *tanneri* but agreed in general with Ridgway's description of *coryi.* Lowery and Monroe (1968, p. 43) included Cat Island in the range of *G. r. coryi,* presumably on the basis of Paulson's statement.

In an effort to secure additional Bahama Yellowthroats, Donald W. Buden visited the islands of Cat, Eleuthera, and Andros. He was able to secure a moderate series of birds from Cat Island where

they were not uncommon, but secured only one on Eleuthera and none on Andros; the latter island was only briefly visited. In this regard, Ronald F. Klinikowski and I spent 18 days on Eleuthera in 1961, and encountered no *Geothlypis rostrata*; I have not seen the bird on New Providence, despite regular search for it over several years. Such observations are of course at best negative, but do indicate that on some islands *G. rostrata* may be either uncommon or that the populations may vary in density with changing ecological conditions. As preliminary studies of our material, along with borrowed specimens, progressed, it became evident that more birds from Andros would be most pertinent; accordingly, the author and James A. Rodgers, Jr., visited Andros for five days in November 1968 and during that period secured four birds and saw several more. The habitat was primarily coppice; *G. rostrata* was most common in patches of coppice surrounded by pinewoods (as, for instance, near Red Bay on northern Andros) and was encountered less abundantly in extensive stands of high and uninterrupted coppice (such as just north of Mastic Point).

I have examined 82 specimens of *G. rostrata*, distributed by islands as follows: *rostrata*, New Providence, 14 males, 4 females, Andros, 11 males, 2 females; *tanneri*, Grand Bahama, 20 males, 6 females, Great Abaco, 7 males, 1 female; *coryi*, Eleuthera, 8 males, 2 females, Cat, 4 males, 3 females. All series include freshly collected material (1960-1968) except the New Providence series which is composed of birds collected in the late 1800's. However, comparing freshly collected and old specimens of *tanneri* from Grand Bahama, I can discern no differences in depth of pigmentation, either dorsally or ventrally; therefore I feel confident that recently collected New Providence birds would differ very little or not at all from these older specimens, and comments on the color of topotypical *G. r. rostrata*, based on the old series, is very probably valid.

Todd (1911, p. 246) diagnosed males of the three subspecies on the basis of color: *rostrata* is characterized by having the crown decidedly grayish, the superciliaries faintly yellow-tinged, the back dull olive green, and the flanks greenish yellow; *tanneri* has the crown more greenish (only superficially grayish) the superciliaries decidedly yellow in front, the back brownish olive green, and the flanks brownish olive yellow; in *coryi*, the crown is decidedly yel-

lowish green, the superciliaries are bright yellow, the back bright olive green, and the flanks greenish yellow. No differences in size were considered important. Hellmayr (1935) confirmed Todd's diagnoses.

For dorsal coloration and pattern of males the following observations are pertinent. Of the three currently recognized populations, Eleuthera *coryi* are the most brightly colored, with back distinctly bright yellow-green, yellow superciliary stripes, and crowns only slightly (if at all) more gray than the dorsal plumage. Cat *coryi* are basically similar in color to Eleuthera males but tend on the average to be perhaps a little brighter (more yellow). New Providence *rostrata* are distinctly less yellow than any *coryi* males, have the crown pale gray with the very pale gray (almost white or with but a touch of very pale yellow) superciliary line blending into the very pale anterior margin of the crown patch. Thus, the posterior margin of the frontal portion of the black mask is outlined with very pale gray in most specimens. Andros *rostrata,* on the other hand, are darker (more olive green and thus like more northern *tanneri*) dorsally, have the crown dark gray and the superciliary lines usually dark gray (occasionally yellowish, occasionally pale gray) and never outlining the posterior frontal portion of the black mask with pale gray. Grand Bahama male *tanneri* are slightly darker than Andros *rostrata* (dark olive green) with a dull greenish gray crown, superciliary lines dull gray to dull yellowish gray and not outlining the frontal portion of the mask posteriorly. Great Abaco male *tanneri* are like Grand Bahama males, except that they tend to be slightly grayer dorsally (more gray than Andros *rostrata*), have the crown paler gray than Grand Bahama males, and have the superciliary lines paler gray (at times almost white) and very faintly outlining the posterior edge of the frontal portion of the mask. As far as dorsal color and pattern are concerned, I distinguish the following groupings: 1) Grand Bahama (including Great Abaco, where the birds are somewhat grayer), 2) New Providence, 3) Andros, 4) Eleuthera and Cat (where the birds are slightly brighter).

By far the brightest yellow birds, as far as ventral color is concerned, are Cat and Eleuthera *coryi*; the specimens from Cat are even brighter than those from Eleuthera and have the olivaceous flank feathers less brownish than do Eleuthera *coryi*. Males from

Cat Island also appear to have the lateral portions of the black mask much broader and more extensive than Eleuthera *coryi*, but this may be an artifact of the preparation of the skins. However, Paulson's single Cat male agrees in this character with the four Cat males collected by Buden, and Buden's Eleuthera male agrees with those collected by previous ornithologists on Eleuthera and not with his own Cat Island skins. New Providence, Andros, Grand Bahama, and Great Abaco males are all comparable in depth of ventral yellow pigmentation, although Abaco males have the flank feathers more deeply brown than any other sample and generally also seem to have the ventral yellow slightly paler. Andros (*rostrata*) and Grand Bahama (*tanneri*) are quite comparable in ventral color. On the basis, then, of ventral pigmentation, I distinguish two groups: 1) Eleuthera and Cat (*coryi*), and 2) all other islands (*rostrata* and *tanneri*). The more impressive pigmental features are dorsal rather than ventral in *G. rostrata.*

Since I have fewer females than males, variation in color in the former sex is less clear than it is in males. However, dorsally, Eleuthera-Cat Island females are much paler (less grayish or brownish) than females from elsewhere, New Providence females are about equally as pale as female *coryi* but lack the yellowish tinge, Andros females resemble Grand Bahama-Great Abaco females in being the darkest (most olivaceous). Certainly the populations which are most distinctly sexually dichromatic dorsally are those on Cat and Eleuthera, in which the females are much less brightly colored dorsally than are the males. In ventral color, the situation parallels that of males. Females from Eleuthera and Cat are the brightest yellow (although they are distinctly less bright than the corresponding males), and females from all other islands are quite comparable in being pale yellow to very pale yellow (often with the central feathers whitish to white) below. In female *tanneri* and *rostrata*, the brownish flank feathers are conspicuous against the remainder of the belly color, whereas in female *coryi* the flank feathers are much less brown (olivaceous) and are much less obvious.

Table 3 gives means and extremes of four measurements of male *Geothlypis rostrata* from six populations. Inspection of this table indicates that populations assigned to *tanneri* (Grand Bahama-Great Abaco) are remarkably similar in all measurements, the greatest discrepancy being in data for bill length (tip of bill to

TABLE 3

Measurements (in millimeters) of males of six populations of *Geothlypis rostrata*, arranged from north to south and west to east in the Bahama Islands. Bill measurement equals chord from anterior border of naris to tip. Low extreme of tail for Grand Bahama *tanneri* is from specimen in extremely worn plumage.

	N	Tail	Wing Chord	Bill	Tarsus
tanneri (Grand Bahama)	16	60.5 (57.6-62.5)	61.2 (58.3-66.7)	10.8 (10.2-11.7)	21.0 (20.2-21.6)
tanneri (Great Abaco)	7	60.6 (59.0-62.0)	60.8 (58.5-62.1)	10.1 (9.7-11.1)	20.8 (19.9-21.4)
rostrata (New Providence)	14	61.2 (58.3-63.0)	65.0 (61.1-72.0)	11.3 (10.2-12.2)	21.6 (20.6-22.7)
exigua (Andros)	11	57.7 (54.9-62.0)	60.5 (57.6-67.9)	10.8 (10.3-11.6)	21.2 (20.5-22.0)
coryi (Eleuthera)	8	60.4 (58.4-62.7)	62.9 (59.9-65.5)	10.9 (10.4-11.4)	20.5 (20.1-21.3)
coryi (Cat)	4	57.3 (55.0-59.4)	63.5 (62.1-65.2)	10.8 (10.5-11.1)	20.8 (20.1-21.6)

anterior margin of naris). Based on both color data and measurements, *G. r. tanneri* seems a well characterized subspecies which shows only limited chromatic variation and which occupies the islands of the Little Bahama Bank.

The situation with the two populations assigned to the nominate subspecies is quite different. In measurements of tail and wing chord, New Providence *rostrata* stand at the upper extreme of all specimens measured, and Andros *rostrata* at the lower. In addition, the New Providence birds have the highest mean measurements of bill and tarsus, with Andros birds showing lower means in both cases, but not at the lower extreme. Taking into consideration the chromatic differences outlined above, I consider that *Geothlypis rostrata* from Andros are not identical to their New Providence relatives. The chromatic differences are striking: comparable differences are not shown in any two populations which I assign to either *tanneri* or *coryi*, and additionally the combination of characters shown by Andros specimens are not matched by any other sample. Accordingly, I hereby resurrect *exigua* Ridgway, 1902, (type locality, Fresh Creek, Andros Island, Bahama Islands) for these Andros birds.

The two populations which are considered currently as *coryi* differ between themselves mensurally. Cat Island males have shorter tails, and the amount of overlap between the two populations in this character is slight (58.6-62.7 in Eleuthera birds, 55.0-59.4 in Cat birds). In wing chord and tarsus measurements, Cat Island males average slightly greater, and the means of bill measurements are almost identical, although Eleuthera *coryi* have a slightly higher upper extreme.

Because the series of females is less extensive than is that of the males, the mensural differences between females is less easily shown; these data are not included in Table 3. In measurements of wing chord, the single Abaco *tanneri* female has the lowest measurement (54.2) of all females studied. Five female *tanneri* from Grand Bahama have a mean wing chord measurement of 56.5 (56.0-58.5), so that the Abaco female falls below the lower limit of the Grand Bahama females. Wing chord means of females from New Providence, Andros, and Eleuthera are very similar (59.6, 59.3, 59.2) with Cat females having a lower mean (57.9),

but the range of measurements of Cat females (55.9-61.3) completely embraces the extremes for females from these other islands.

In tail length, once again the lowest measurement of all females is the single Abaco female (51.0) whereas the series of six Grand Bahama females have measurements of 55.7-56.6. Tail measurements of New Providence, Andros, and Eleuthera females have similar means (56.7, 57.7, 58.3); although these differences are more striking than those in the male samples from these same islands, the series of females are considerably smaller, and I attach little significance to the differences observed. On the other hand, the tail measurements of females from Cat show a very low mean (53.8), and very low extremes (51.9-56.5); all birds were taken in either November or March and do not show conspicuously worn plumage. In fact, Cat females are completely separable (51.9-56.5) from Eleuthera females (56.9-59.3) on the basis of this measurement. It should be recalled that Eleuthera and Cat males likewise have strongly different means (60.4, 57.3) and extremes (58.6-62.7, 55.0-59.4) in this measurement, although there is some overlap in the case of tail measurements in males. It seems likely that Eleuthera and Cat *Geothlypis rostrata* have diverged from each other (at least as far as tail length is concerned) to a greater degree than have the two populations of *G. r. tanneri*, for instance. If the chromatic differences or the single possible pattern difference (extent of the black mask posteriorly) could be confirmed by additional material, it seems likely that the Cat Island birds should be distinguished nomenclatorially from those from Eleuthera. I am not prepared to do so at this time.

The distribution of the subspecies of *G. rostrata* is confined to islands of the Great and Little banks. The Little Bank is occupied by *G. r. tanneri*; considering the similarity between the two *tanneri* populations, it seems likely that the Abaconian birds have been relatively recently derived from those from Grand Bahama, or vice versa. The Great Bahama Bank is essentially a U-shaped bank, with the deep Tongue of the Ocean separating the two arms of the U, oriented with the opening toward the north. Andros lies on the western arm of the U, New Providence and Eleuthera on the eastern arm. Cat Island is usually associated with the eastern arm also (Cat is quite close to Eleuthera) but in actuality Cat lies on its own bank. The differences between *exigua* (on the western

arm of the bank) and *rostrata* (on the eastern arm) are not surprising. Despite the proximity of Andros and New Providence (about 40 km), these two islands lie on different sections of the bank and, separated by the deep Tongue of the Ocean, have presumably never been directly connected. On the other hand, the shallow banks connecting Eleuthera and Cat Island suggest that since the Pliocene, these two islands have been variously associated with each other and for varying lengths of time. Thus, differentiation between *exigua* and *rostrata* is more pronounced than between the two *coryi* populations (which however seem to have diverged in at least one character); each member of the former pair of subspecies has had an independent history and the two populations have never been directly in contact, whereas the latter pair of populations may have been in contact at various times and for varying durations during the more recent geologic history of the Bahama Islands.

Specimens examined: *G. r. tanneri*: *Grand Bahama,* Bootle Bay, 3.5 mi. E West End, 1 (AS); 5.5 mi. E West End, 2 (AS); 1 mi. E Eight Mile Rock, 2 (AS); Queen's Cove, 1 (AS); 8.4 mi. E Freeport (airfield), 1 (AS); 17 mi. E Freeport, 1 (AS); 1.2 mi. W McLean's Town, 1 (AS); 1.0 mi. W McLean's Town, 1 (AS); 0.5 mi. W McLean's Town, 1 (AS); 2.2 mi. E McLean's Town, 1 (AS); 2.5 mi. E McLean's Town, 1 (AS); 4.1 mi. E McLean's Town, 3 (AS); 4.2 mi. E McLean's Town, 2 (AS); 4.2 mi. E. McLean's Town, 2 (AS); 7.0 mi. W High Rock, 1 (AS); 35.5 mi. E Lucaya, 1 (AS); 36 mi. E Lucaya, 1 (AS); 45 mi. E Freeport, 1 (AS); no data other than Grand Bahama, 3 (FMNH); *Great Abaco,* 6 mi. NW Treasure Cay, 3 (AS, LSUMZ); 16 mi. NW Treasure Cay, 1 (AS); 15 mi. S Lake City, 1 (AS); no data other than "Abaco", 3 (FMNH).

G. r. rostrata: *New Providence,* Nassau, 15 (AMNH, FMNH); no data other than New Providence, 2 (USNM); "Bahama Islands", 1 (FMNH).

G. r. exigua: *Andros,* 1.5 mi. S Fresh Creek, 1 (AS); 1 mi. N Mastic Point, 2 (AS); 2 mi. ESE Red Bay, 2 (AS); no data other than Andros, 8 (ANSP, FMNH).

G. r. coryi: *Eleuthera,* 2.3 mi. SE Governor's Harbour, 1 (AS); no data other than Eleuthera, 9 (AMNH, FMNH, USNM); *Cat Island,* The Bight, 1 (AS); Tea Bay, 1 (AS); 9.6 mi. S Bluff Settlement, 1 (AS); 8.3 mi. SE Old Bight, 1 (AS); 3.0 mi. E Old Bight, 1 (AS); 0.9 mi. E Old Bight, 1 (AS); 1.8 mi. N Bennett's Harbour, 1 (AS).

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Post-Columbian Birds from Abaco Island, Bahamas

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THE island of Abaco in the Bahamas has no record of fossil birds until now. Such information from elsewhere in the Bahamas is limited to three reports of bird remains on Great Exuma (Wetmore, 1937), Crooked Island (Wetmore, 1938), and New Providence (Brodkorb, 1959).

During July of 1969 Dr. E. Lowe Pierce, of the University of Florida, and Donald L. Malone partially excavated a cave deposit on the Great Abaco Island. The cave is approximately 10 miles south of Marsh Harbor. A small amount of matrix from this excavation contained many bones of mammals and birds. The bones of the rodents from this material are *Rattus* species, and indicate that the avian bones collected with these rodents are Post-Columbian. Therefore, for the most part, these bird bones correspond to those of birds which currently inhabit the Bahamas.

FAMILY COLUMBIDAE

Columba leucocephala Linnaeus. White-crowned Pigeon. Left coracoid, alar digit, left tarsometatarsus. *C. leucocephala* was previously reported as a fossil in the Bahamas from Crooked Island and New Providence.

Columbigallina passerina (Linnaeus). Ground Dove. Right coracoid. *C. passerina* has not previously been reported as a fossil in the Bahamas.

FAMILY CUCULIDAE

Coccyzus americanus (Linnaeus). Yellow-billed Cuckoo. Left humerus. The humerus has a deep capital groove which corresponds to *C. americanus.* Also, *C. minor* is heavier than *C. americanus* or the fossil. The only previous fossil record of *C. americanus* is from Haile, Florida. (Ligon, 1966)

Crotophaga ani Linnaeus. Smooth-billed Ani. Left ulna, right femur. *C. ani* has not been reported previously as a fossil in the Bahamas.

FAMILY PICIDAE

Dendrocopos villosus (Linnaeus). Hairy Woodpecker. Right humerus, with proximal end broken, right ulna, left femur, with both proximal and distal ends broken, distal portion of right tibiotarsus. The only previous fossil record of *D. villosus* is from California. (Miller and Demay, 1942)

FAMILY TYRANNIDAE

Tyrannus dominicensis (Gmelin). Gray Kingbird. Mandible, quadrate, lower end of coracoid, left scapula, one right and the shafts of two left humeri, left ulna, portion of synsacrum, two left and distal portion of one right femur. *T. dominicensis* has not previously been reported as a fossil in the Bahamas.

Tolmarchus caudifasciatus (d'Orbigny). Loggerhead Flycatcher. Shaft of left ulna, two right and proximal end of left tarsometatarsus. *T. caudifasciatus* has not previously been reported as a fossil in the Bahamas.

FAMILY MIMIDAE

Mimus polyglottos (Linnaeus). Northern Mockingbird. Portion of mandible, synsacrum, distal portion of left tibiotarsus. *M. gundlachii,* which also occurs on Abaco, was not available for comparison. *M. polyglottos* has not previously been reported as a fossil in the Bahamas.

FAMILY TURDIDAE

Mimocichla plumbea (Linnaeus). Red-legged Thrush. Proximal end of left humerus, shaft of left tibiotarsus, left tarsometatarsus. *M. plumbea* was previously reported as a fossil in the Bahamas from Great Exuma.

FAMILY VIREONIDAE

Vireo solitarius (Wilson). Solitary Vireo. Portions of two mandibles, two left humeri, right and left tarsometatarsi. The humeri agree with humeri of both *V. solitarius* and *V. flavifrons* in size, but measurements show *V. flavifrons* to differ from *V. soli-*

tarius and from the fossil by having less depth at both the proximal and distal ends. Also, the tarsometatarsi of *V. flavifrons* are shorter than those of *V. solitarius* and of the fossil. There is no previous fossil record of *Vireo solitarius.*

FAMILY PARULIDAE

Dendroica tigrina (Gmelin). Cape May Warbler. Right coracoid, portion of scapula, right ulna, one left and proximal end of right tibiotarsus, portion of sternum. The fossil agrees in size with *D. pensylvanica, D. fusca, D. dominica, D. caerulescens, D. virens,* and *D. tigrina.* Only *D. virens* and *D. tigrina* agree with the fossil coracoid in having the hyposternal process broadly flared. The tibiotarsus of *D. virens* is much more slender than that of *D. tigrina* or the fossil. There is no previous fossil record of *Dendroica tigrina.*

Protonotaria citrea (Boddaert). Prothonotary Warbler. Portion of mandible, right coracoid, right ulna, left humerus. There is no previous fossil record of *P. citrea.*

Seiurus aurocapillus. (Linnaeus). Oven Bird. Right humerus, right carpometacarpus, right femur, right tarsometatarsus. The humerus of *S. aurocapillus* differs from those of *S. noveboracensis* and *S. motacilla* in that its shaft and the width of its condyls are thicker. Also, the femur of *S. aurocapillus* is larger than the femurs of these other two species. *S. aurocapillus* has not previously been reported as a fossil in the Bahamas.

Vermivora pinus (Linnaeus). Blue-winged Warbler. Right and left humeri. The only previous fossil record of *V. pinus* is from Vero Beach, Florida (Weigel, 1963).

Wilsonia citrina (Boddaert). Hooded Warbler. Right humerus, proximal end of right tibiotarsus. There is no previous fossil record of *W. citrina.*

FAMILY THRAUPIDAE

Spindalis zena Linnaeus. Striped-headed Tanager. Portion of mandible, one left and two right carpometacarpi, two right tarsometatarsi. *S. zena* has not previously been reported as a fossil in the Bahamas.

Family Icteridae

Agelaius phoeniceus (Linnaeus). Red-winged Blackbird. Right coracoid, left humerus, left ulna, pelvis. *A. phoeniceus* has not previously been reported as a fossil in the Bahamas.

Family Fringillidae

Loxigilla violacea (Linnaeus). Greater Antillean Bullfinch. Right scapula, two left coracoids, two left humeri, proximal end of right ulna, radius, synsacrum, right and left femurs and distal end of left femur, right tarsometatarsus, and four right tibiotarsi. *L. violacea* has not previously been reported as a fossil in the Bahamas.

Passerina ciris (Linnaeus). Painted Bunting. Left carpometacarpus, right femur, right tibiotarsus, two right tarsometatarsi. *P. ciris* and *P. cyanea* are very similar, but the fossil tibiotarsus corresponds most closely to that of *P. ciris* in having a much shorter and less prominent outer cnemial crest and a broader groove behind this crest than *P. cyanea*. There is no previous fossil record of *P. ciris*.

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Vol. 33 December, 1970 No. 4

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Pilot Whales Mass Stranded at Nevis, West Indies

David K. Caldwell, Warren F. Rathjen,
and Melba C. Caldwell

The pilot whale or blackfish, *Globicephala macrorhyncha* (Gray), has been recorded from a number of West Indian localities which include Cuba, the Bahamas, Haiti, Puerto Rico, St. Croix, Guadeloupe, Dominica, St. Lucia, and St. Vincent (Caldwell and Erdman, 1963). Fenger (1958, p. 102) also recorded blackfish from near Bequia in the Grenadines, and Murphy (1947, p. 18) from off Martinique.

The pilot whale is well known at sea throughout the West Indies, and is met in sufficient numbers to support small local fisheries for food and oil near various islands of the Lesser Antilles (Brown, 1945; Hickling, 1950; Caldwell and Erdman, 1963). While there are cases of individuals dead on the beach, a group stranding in the islands has, to our knowledge, never been reported. Pilot whales are notorious for stranding en masse along the Atlantic mainland coast of the United States and elsewhere in the world, and whether the lack of reported strandings in the West Indies is due to physiographic or hydrographic conditions, or merely to lack of communication is not known.

It is therefore of interest to note the stranding of 16 pilot whales on or about 12 May 1969 on the beach in the Butler's area on the northeastern (windward) side of the island of Nevis. This is also the first record of the pilot whale from Nevis under any circumstances. As can be seen in Fig. 1, the shore at that point is strewn with large rocks. The surf is rough as it receives the full force of the easterly trade winds which almost constantly sweep the eastern shores of these islands.

Fig. 1. Stranded pilot whales (*Globicephala* cf. *macrorhyncha*) at Nevis, West Indies.

Mr. W. O. Parris of the Ministry of Agriculture and Labour at St. Kitts kindly provided us with the details and photographs of the stranding upon which this report is based. He noted that the largest animal reported was some 18 feet in length.

In the photographs of the stranded animals, clearly of the genus *Globicephala*, the pectoral flippers appear comparatively short. True (1889, p. 183 f.) and Fraser (1950, p. 59) noted the value of the character of relative flipper length to distinguish the shorter-finned, more southerly *G. macrorhyncha* (=*G. brachyptera*) from the longer-finned, more northerly *G. melaena* (=*G. melas*). We therefore believe the Nevis animals to be *G. macrorhyncha*. In addition, all specimens of *Globicephala* that we have seen from the West Indies have proven to be *G. macrorhyncha* and as Caldwell and Erdman (1963) stated, it is the species to be expected there. There is no reason to suspect that the Nevis record would apply to any other species.

The photographs of the Nevis animals are sufficiently clear to show that at least one has a distinct light throat patch and a thin

light streak connecting it with the inguinal area (Sergeant, 1962). We have seen the same pigmentation on positively identified specimens of *G. macrorhyncha* from St. Vincent in the Lesser Antilles.

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Redescription of *Sphaerodactylus stejnegeri* Cochran

Lewis D. Ober

Cochran (1931) described the gecko *Sphaerodactylus stejnegeri* from Haiti; the description was based upon three specimens, the type and two paratypes. In a second paper (1941) she had no new material and quoted verbatim from her 1931 paper.

Mertens (1939) discussed a single male specimen of this form brought by him to Frankfurt-am-Main. He described it thus (in free translation):

> The markings are rather washed out; the dark canthal stripe is missing, the dark occipital band is barely discernible. Present are only a grey brown crossband on the neck and two widely separated (bands) on the back; a fourth (band) is formed just behind the tail-root; these crossbands are anteriorly and posteriorly brightly edged.

Cochran's description was of a 31 mm specimen which was strongly patterned. Mertens' specimen was 26 mm and had a fading pattern. Since most of the sexually dichromatic sphaerodactyli have young males and females patterned much like the female, I assume that Mertens diagnosed his specimen as a transitional male.

Grant (1949) discussed a series of 33 live specimens received from Port au Prince and firmly established sexual dichromatism in this species of lizard. He gave a characteristic of the escutcheon which separates these males from *Sphaerodactylus cinereus,* which they closely resemble. He described the male as being without pattern, with a dark occipital area and with the entire upper surface light to medium brown with minute specks on the scales, and with the underside clear cream color. Later on, however, he quoted Mr. Anthony Curtiss, the collector of his specimens, as saying, "These are small brownish sphaerodactyls with orange throat and tail." Grant did not indicate that he observed an "orange throat and tail." He then went on to speculate that males and females hatch with a female-like color pattern; males lose the pattern entirely and females add the "speckled areas" between the dark bands as they mature.

Schwartz and Thomas (1964, p. 331) discussed *S. stejnegeri*

briefly, pointing out that Cochran's inclusion of the Tiburon Peninsula in the range was probably in error. Thomas and Schwartz (1966) subsequently discussed the species in more detail, having examined 29 specimens and described the male and female color patterns of preserved specimens. They described the male as "unicolor tan or yellowish tan above, venter as in females."

It appears that while the female color pattern of *Sphaerodactylus stejnegeri* is rather well established, neither the juvenile nor the male has been adequately described from living material.

On 30 June 1969, while refreshing ourselves at a spring on the road to Ganthier in the Cul de Sac Plain, my son began probing in a dead limb of a calabash tree (*Crescentia cujete*). He secured first a female and then a juvenile *S. stejnegeri*. We encouraged the local Haitians to secure more for us and we were rewarded, after purchasing 30-40 *Sphaerodactylus brevirostratus*, with a handsome full-grown male. Because of the transitory nature of the color of the male after death and the fact that the juvenile has never been described, the male and juvenile are herewith described from life.

Male. LDO 7-5977. Snout to vent, 28.2 mm. Dorsal and lateral body drab grey with just a tinge of brown or tan anteriorly. The head is almost all yellow dorsally, laterally, and ventrally. A slightly darker, slightly bluish teardrop-shaped spot, with blunt end forward, extends posteriorly from just behind the eyes on the top of head about two-thirds of the way along the neck. There is a dark smudge between the eyes extending slightly on to the snout. The tail is reddish-orange dorsally and laterally. The distal two-fifths are marked with numerous black punctations. The dark bands on the tail are caused by heavier concentrations of the punctations on certain scales. From dorsal aspect, the legs are the same color as dorsal and lateral body, but lighter in shade. Ventrally, the entire underside of the body is light cream, almost white and the undersides of the appendages are even lighter. The chin and throat are the bright yellow of the head. The tail is orange ventrally, darker proximally, more brilliant distally.

Juvenile. LDO 7-5976. Snout to vent, 19.0 mm. Ground color is a neutral or slightly pinkish-grey with jet-black sharply defined bands in the same positions as they are found in the female. In the juvenile, the bands go completely around the body whereas in the adult female, only the anteriormost does; all others are interrupted.

The bands in the juvenile lack the white or light area in front and behind, and the interband areas are immaculate. There is one band on the head behind the eyes, extending anteriorly through the eye and along the canthus. A second band goes around the neck and there are two bands around the body. There are five bands around the tail, with the tip of the tail also black. Limbs are immaculate light grey dorsally and ventrally. Under microscopic examination, the light areas of male, female and juvenile are heavily peppered with dark punctations.

The conspicuousness of the yellow head and orange tail of the male could not be overlooked. The absence of any mention of this by Grant in his own observations leads to the possible conclusion that these colors may be seasonal and have faded before the specimens reached his hands.

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Soil Algae of Northwest Florida

Jon H. Arvik

Reports on the algal flora of Florida have been primarily discussions of particular taxons (Brannon, 1945, 1952) or regions (Nielsen and Madsen, 1948, 1948a; Crowson, 1950) or are truly taxonomic works in somewhat greater detail (Nielsen, 1954, 1954a, 1955, 1955a, 1956; Nielsen and Madsen, 1956, 1956a). Studies of Florida soil algae were made by Smith and Ellis (1943) and Smith (1944); however, these were concerned with characterization of an algal ecosystem rather than taxonomy. The works of Tilden (1910) and Drouet (1968) also include information on Florida algae.

Approach

This investigation was undertaken to provide a portion of a continuing program of ecological research sponsored by the Air Force Armament Laboratory, Eglin AFB, Florida. The Eglin Reservation, occupying approximately 750 square miles in northwestern Florida, was the study area. Eglin is bounded by Alaqua Creek to the east, the Yellow River to the west and north, Choctawhatchee Bay to the south, and includes portions of the Southern Coastal Plain and Gulf Coast Flatwoods. Soil types vary considerably in the area (Huckle and Weeks, 1965), but are generally moderately thick acid sands of either Lakeland-Eustis-Blandon or Lakeland-Eustis-Norfolk association (Smith et al., 1967).

The specific sampling areas included forested areas of longleaf pine (*Pinus palustris* Mill.), sand pine (*P. clausa* Chapm. Vasey), and turkey oak (*Quercus laevis* Walt.), reforested areas planted to slash pine (*P. elliotti* Englm. var. elliotti), and areas mechanically cleared and left untended. Creeks, ponds and lowland swamps were not included.

Ten sites of 0.01 acre each were selected throughout the Reservation. None of the sites had a history of herbicide treatment. Collections were made in September, 1967, January, March, June, August, and October, 1968. Samples were taken from two levels in the soil. Level A included the litter of the surface and the first centimeter of soil. Level B samples were an amalgam of the soil

between one and 15 cm. Samples were taken with sterile wooden tongue depressors and were transported to the laboratory in sterile disposable dishes. Approximately 100 grams of soil were collected from three random points in each site on each sample date. In the laboratory, the soil was divided to provide four cultures from each original sample.

The moist plate culture method of Willson and Forest (1957) was used with slight modifications. Sterile filter paper was placed in 100 mm sterile disposable Petri dishes, after which approximately 25 gm of the sample soil were added. The algae were cultured with sterile Bristol's solution under fluorescent lights in 12-hour light/dark cycles at 300 foot-candles. Temperatures were allowed to vary ± 3 C from 25 C. The second method of culture preparation was identical to the first except an additional piece of sterile filter paper was placed directly on the culture soil and moistened with the nutrient solution. Many algal forms grew through the paper, permitting easier observation of gross colony morphology and aiding isolation of the organisms into cultures. Standard isolation techniques were used to obtain unialgal or axenic cultures of the green algae. Life cycle studies as described by Starr (1955), Deason and Bold (1960) and others were performed as required to determine the species of selected organisms. No effort was made to obtain pure cultures of the bluegreen algae.

RESULTS AND DISCUSSION

Thirty-eight organisms were identified. Thirteen of the Chlorophyta and three of the Cyanophyta were unicellular forms. Algae located in every sample included at least one species of each of the genera *Chlamydomonas, Chlorococcum, Chlorella, Microcoleus, Nostoc, Oscillatoria,* and *Schizothrix.* In the great majority of cases, *Chlorococcum, Nostoc,* and *Schizothrix* were represented by two or more species. Presumably because of seasonal variations and lower population densities, most of the other algae were located sporadically through the sampling period, but few were not universally distributed on all sample plots or in both sample levels. A species of *Spongiococcum* was the only alga found repeatedly in a single location, though *Rivularia* was cultured only once in the entire study.

The dominant genus in terms of biomass in culture was *Nostoc.*

Two of the three species located in the study were present in every culture, *N. muscorum* Ag. and *N. ellipsosporum* (Desmaz.) Rabenh. The most frequently located alga was *Schizothrix calcicola* (Ag.) Gom. This is probably the case in most previous studies of soil algae, since a recent monograph has transposed the majority of the family Oscillatoriaceae into that species (Drouet, 1968). A complete listing of the algae identified in this study is as follows:

CHLOROPHYTA, Family Chariaceae

Characium ambiguum Herm.
Characium sp.

Family Chlamydomonadaceae

Chlamydomonas pyrenoidosa Deason and Bold
C. typica Deason and Bold

Family Chlorococcaceae

Chlorococcum ellipsoideum Deason and Bold
C. diplobionticum Hern.
Spongiococcum sp.

Family Euglenaceae

Euglena sp.

Family Mesotaeniaceae

Cylindrocystis Brebissonii Menegh.

Family Oocystaceae

Chlorella vulgaris Beyer.
Chlorella sp.

Family Protodermataceae

Protococcus viridis C. A. Agardh.

Family Scenedesmaceae

Scenedesmus sp.

Family Ulotrichaceae

Hormidium subtilissimum Mattox and Bold
H. flaccidum Mattox and Bold
Stichococcus bacillaris Naeg.
S. subtilis (Kuetz.) Klerk.
Ulothrix tenerrima Kuetz.

Family Zygnemataceae

Zygogonium ericetorum Kuetz.

CYANOPHYTA, Family Chroococcaceae

Anacystis marina Drouet and Daily
Coccochloris aeruginosa Drouet and Daily
C. peniocystis Drouet and Daily

Family Nostocaceae

Nodularia sp.
Nostoc commune Vauch.

N. ellipsosporum (Desmaz.) Rabenh.
N. muscorum Ag.

Family Oscillatoriaceae

Arthrospira brevis (Kuetz.) Drouet
Microcoleus lyngbyaceus (Kuetz.) Drouet
M. vaginatus (Vauch.) Gom.
Oscillatoria lutea Ag.
O. submembranaceae Ar. and Straff
Porphyrosiphon Notarisii (Menegh.) Gom.
Schizothrix arenaria (Berk.) Gom.
S. calcicola (Ag.) Gom.
S. Friezii (Ag.) Gom.

Family Rivulariaceae

Calothrix parietina (Naeg.) Thuret.
Rivularia sp.

Family Stigonemataceae

Fischerella ambigua (Naeg.) Gom.

Soil populations are by nature unstable and respond to changes in moisture, nutrient and mineral content of the soil, light availability to the organisms, distribution and densities of species in the soils, and other factors, including pH and soil type. In studies of North Carolina pine forest soils, Jurgensen and Davey (1968) found an inverse relation between algal numbers and soil pH. They could not culture nitrogen-fixing algae from soils with a pH of 5.4 and lower, though algae of this type were located in abundance from all samples of Eglin pine stand soils with a pH range from 5.0 to 5.4. These algae included *Nostoc muscorum, N. ellipsosporum, N. commune, Calothrix parietina,* and others. However, it has been demonstrated that nitrogen fixation does not occur below a pH of approximately 5.7 (Allison et al., 1937, Fogg, 1947), so though these algae are present, they are limited in what should be their major contribution to a soil ecosystem.

Smith (1944) attempted to determine the algal flora of several different Florida soil types. The Norfolk fine sand flora of his study and the Eglin Norfolk flora generally agree. In some cases where the algae located by Smith were not located in this study, closely related algae were cultured. For example, Smith found *Mesotaenium,* a saccoderm desmid; we did not observe this alga, but did find *Cylindrocystis,* also a member of the Mesotaeniaceae.

It is probable that a characteristic microflora may be found associated with a given soil type, just as the macrovegetation of a

region is influenced by the soil. Since the sample areas of this study were chosen for their similarity, no qualitative variations in the algal flora were attributed to differences in soils. Thus, the list of algae located during the study is a composite from all of the sample sites.

The author is indebted to Dr. Francis Drouet of the Academy of Natural Sciences, Philadelphia, Pennsylvania, for confirmation of many of the species located in the study. In addition, the assistance and suggestions of Dr. Hannah Croasdale of Dartmouth University, Hanover, New Hampshire, are gratefully acknowledged.

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Cyclic Erosion Surfaces in Swaziland

Harm J. de Blij

Recent evidence supporting the hypothesis of continental drift has generated a reassessment of theoretical geomorphological constructs whose fundamental assumptions involve: (1) the former unity of continental landmasses; and (2) their deformation in the process of horizontal movement. Among the earliest of these postulates was that of King (1950). Essentially this was a confirmation and large-scale regionalization of the slope-retreat concept of Penck (1927) and a repudiation of the peneplanation concept of Davis (1922). Arguing that the pediplanation process leaves the core areas of erosion surfaces basically unchanged (though subject to vertical isostatic adjustment), King proposed an intercontinental correlation of cyclic erosion surfaces. Thus the ancient Gondwana surface, supposed to have been the dominant degradational feature across the Gondwana supercontinent prior to its Jurassic-Cretaceous fragmentation, can still be identified in isolated remnants in South America and Africa (King, 1957). Older and younger surfaces can likewise be related, notably the so-called Pre-Karroo Peneplain recognized by Wellington (1937), a vast unconformity demarcating the lower limit of the massive Karroo depositional-extrusive sequence, which simultaneously affected regions of South America, Africa, Antarctica, Madagascar, India, and Australia.

The nature of deformation of erosion surfaces has never been clear. The apparent periodicity of earth orogenesis first detailed by Umbgrove (1947) also appears to be recorded in the geomorphic pattern. Neither orogenic nor epeirogenic principles provided a satisfactory solution to problems revealed by surface mapping, and King (1961) proposed the principle of cymatogeny, a crustal deformation "with a production of smooth arching amounting to thousands of feet though there is little or no deformation of rock strata by folding or faulting . . . the earth's surface is thrown into gigantic undulations or waves, sometimes measuring hundreds of miles across" (p. 2). Thus the cymatogenic, undulating ogeny creates broad arches and domes or open troughs and basins, so that planed surfaces acquire a tilt or warp. Importantly, the degradational processes operating on the elevated areas are complemented by aggradational sequences in the depressed areas, where the ero-

sional record may be more clearly expressed than on the planed surfaces themselves. On a continental scale, therefore, altitude is an unreliable criterion alone in the identification of cyclic erosion surfaces, especially those of Tertiary and pre-Tertiary age.

EROSION SURFACES IN SOUTHERN AFRICA

Apart from small exposures of the Pre-Karroo Peneplain, five erosion surfaces have been recognized in southern Africa (1) the *Gondwana*, a Jurassic surface still observable at elevations of about 10,000 feet on the Drakensberg, and at over 7,000 feet in South West Africa and Angola; (2) the indistinct, Cretaceous *Post-Gondwana;* (3) the early Tertiary *African* surface, which extends over the bulk of the African shield-plateau and corresponds to the Brazilian *Sulamericana;* (4) the late Tertiary *Victoria Falls* cycle, which covers much of the lower part of the African plateau; and (5) the Quaternary *Congo* surface, which marks the margins of the valleys of Africa's major rivers (Fig. 1). Hitherto, little detailed surface mapping has been done, especially in the non-African fragments of Gondwana. Generalized maps on a continental scale have been published by King (1951, 1967), and King has also mapped details of the Natal monocline and the monoclinal deformation of the coastal *Sulamericana* in eastern Brazil as well as the *Great Australian* Tertiary surface in southeast Australia. The work by Pugh (1954) on Nigeria was a pioneering effort, but a massive task remains. Given the apparent confirmation of the drift hypothesis, this is now a matter of some urgency, for the exact identification of erosional levels must precede any precise measurement of their cymatogenic deformation, rate of contraction under slope retreat, and quantitative relationships with their aggradational contemporaries.

EROSION SURFACES IN SWAZILAND

It is toward this goal that the present study is directed. Swaziland, a landlocked country in the southeastern part of Africa, affords a physiography whose range of erosional levels and location relative to major subcontinental structural elements combine to provide an ideal field laboratory (De Blij, 1960). Positioned astride the Great Escarpment of southern Africa, Swaziland's elevations range from over 5,000 feet in the west to well under 1,000 feet in the east (Fig.

2). Situated in the northern sector of the Natal monocline (King, 1940), Swaziland's erosion surfaces have undergone measurable cymatogenic deformation. Unlike the margins of South Africa's

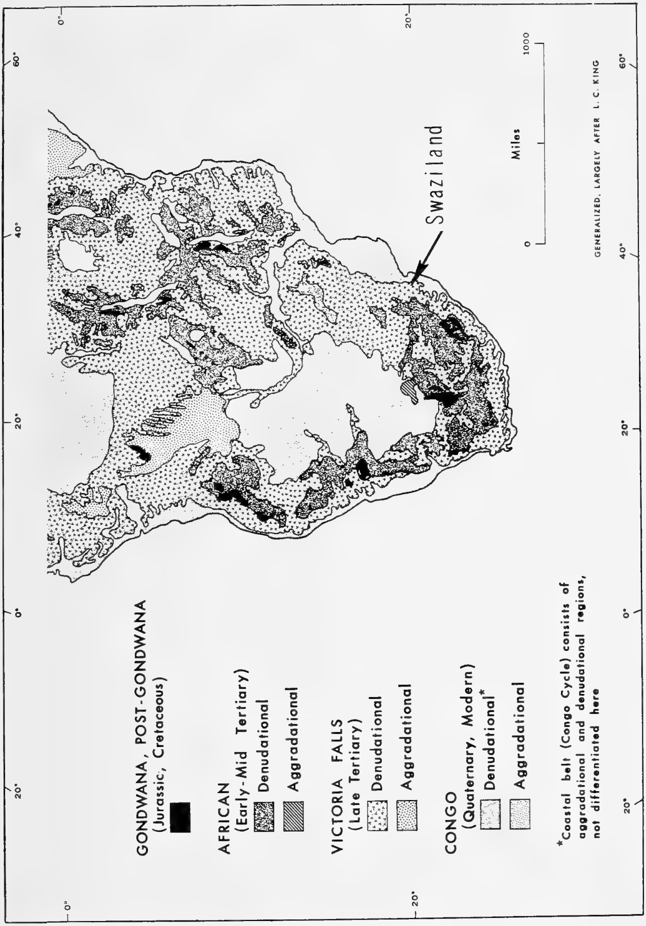
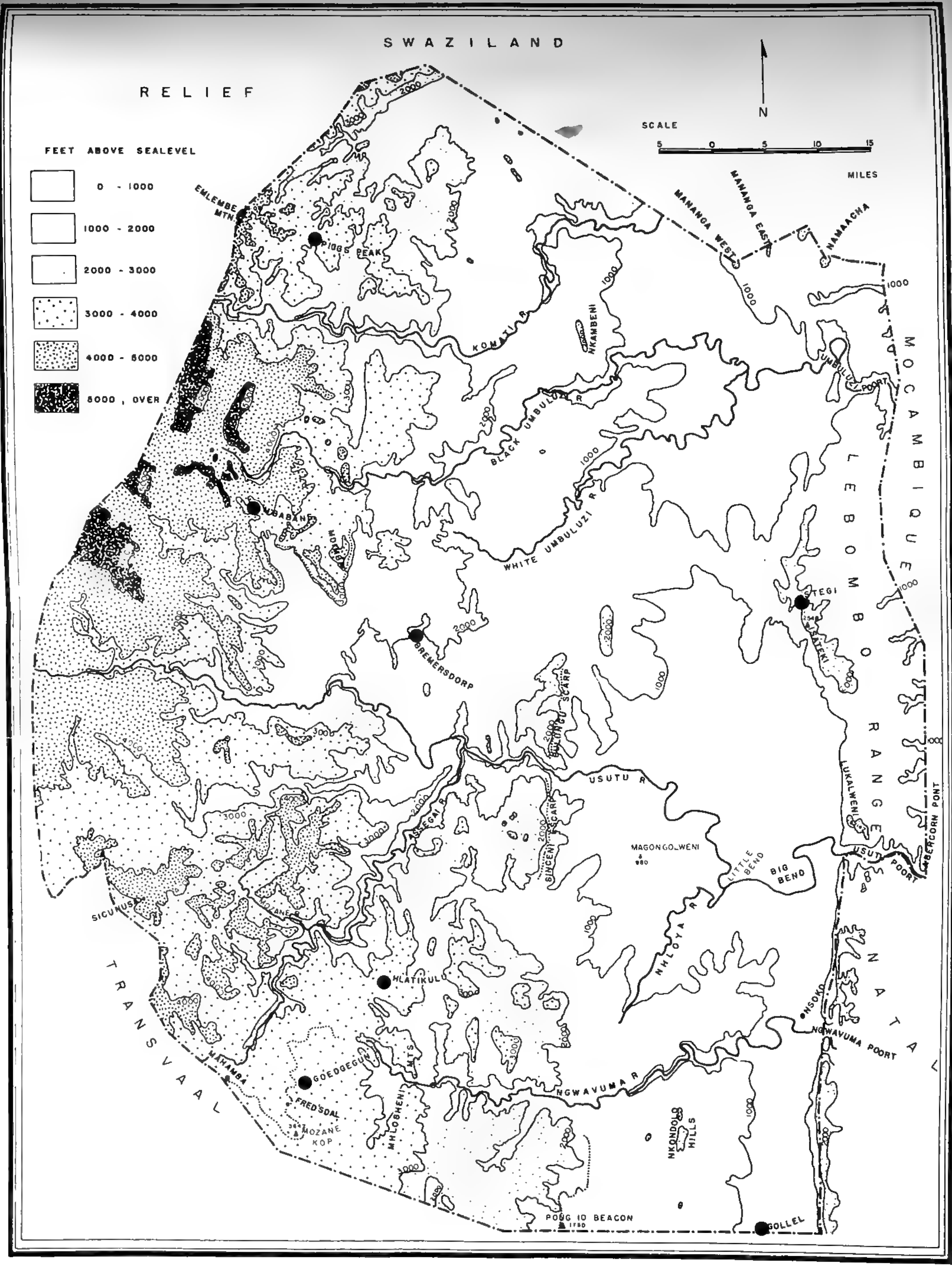


Fig. 1. Erosion surfaces in southern Africa.

Drakensberg, which plunge through a series of steps and a narrow, hilly belt directly into the sea, Swaziland's erosion surfaces are complemented by a subareal aggradational sequence in the Moçambique coastal plain. And again unlike most of the remainder of southern Africa, the step-like decline from the African plateau to the coast is interrupted by a north-south trending, persistent outlier, the Lebombo Range. This combination of circumstances renders Swaziland an especially profitable geomorphic area.

As the topographic map indicates, physiographic provinces in Swaziland trend longitudinally. Based mainly on elevation and its associated vegetation, four such provinces can be identified, locally referred to as (1) the *highveld*, which lies in the west generally above 3,300 feet; (2) the *middleveld*, which trends through the west center of the country at elevations ranging from 1,800 to 3,300 feet; (3) the *lowveld*, in the east center below 1,800 feet; and (4) the *Lebombo*, the western outlier of higher eastern elevations. River drainage is eastward, and the Usutu River possesses the largest catchment basin and the greatest volume of flow annually. Although it has been claimed that the westward facing scarp of the Lebombo is of erosional origin (Wellington 1956), the limited volume of flow of the Usutu and other Swaziland streams, and the fact that these rivers are not underfit in their Lebombo watergaps, has led to doubts regarding the real genesis of the Lebombo Escarpment (De Blij, 1960a). Indeed, it has been suggested that the Swaziland lowveld has the structural attributes of a rift valley, and constitutes part of the southernmost section of the great African rift valley system (De Blij, 1966).

The longitudinal orientation of Swaziland's physiography is mirrored by dominant trends in its geology (Fig. 3). Apart from the strongly folded series of the Swaziland System, the western half of the area is dominated by granites and other crystallines. These form part of the vast African shield, and here as elsewhere they constitute the basement rocks upon which the Karroo sequence was laid down. This sequence is represented in Swaziland by the dolerite-infested Ecca series (no Dwyka tillites have been found exposed) and the lavas that marked the termination of the system, the Stormberg basalts and the Lebombo rhyolites. Thus the highveld and middleveld are sustained dominantly by granites, the lowveld cuts across sandstones of the Ecca as well as basalts, and the


SWAZILAND
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1000 - 2000
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4000 - 5000
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SCALE
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N
EMLEMBE MTN.
PIGG'S PEAK
MANANGA WEST
MANANGA EAST
NAMAACHA
KOMATI R
NKAMBENI
BLACK UMBULUZI R
WHITE UMBULUZI R
UMBULUZI POORT
MOCAMBIQUE
LEBOMBO RANGE
STEGI
MBABANE
BREMERSDORP
USUTU R
ASSEGAI R
SIDVOKODVO
MAGONGOLWENI
LITTLE BEND
BIG BEND
LUKALWENI
USUTU POORT
ABERCORN PONT
SIGUNUSA
HLATIKULU
NHLOYA R
NSOKO
NGWAVUMA POORT
NATAL
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GOLLEL
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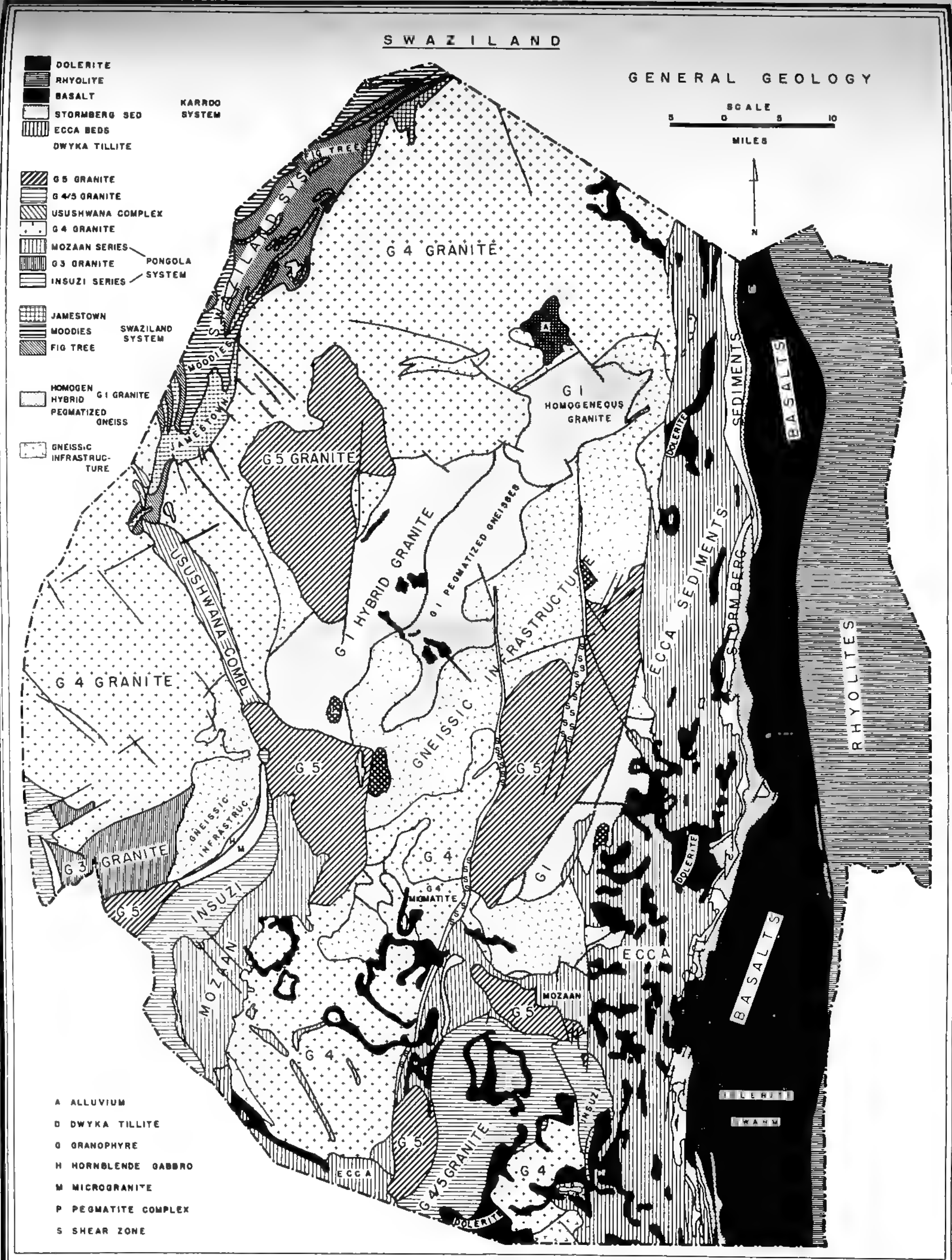
SWAZILAND
GENERAL GEOLOGY
SCALE
5 0 5 10
MILES
N
DOLERITE
RHYOLITE
BASALT
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DWYKA TILLITE
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G 5 GRANITE
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G 4 GRANITE
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PONGOLA SYSTEM
JAMESTOWN
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SWAZILAND SYSTEM
HOMOGEN
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G 1 GRANITE
PEGMATIZED GNEISS
GNEISSIC INFRASTRUCTURE
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D DWYKA TILLITE
G GRANOPHYRE
H HORNBLENDE GABBRO
M MICROGRANITE
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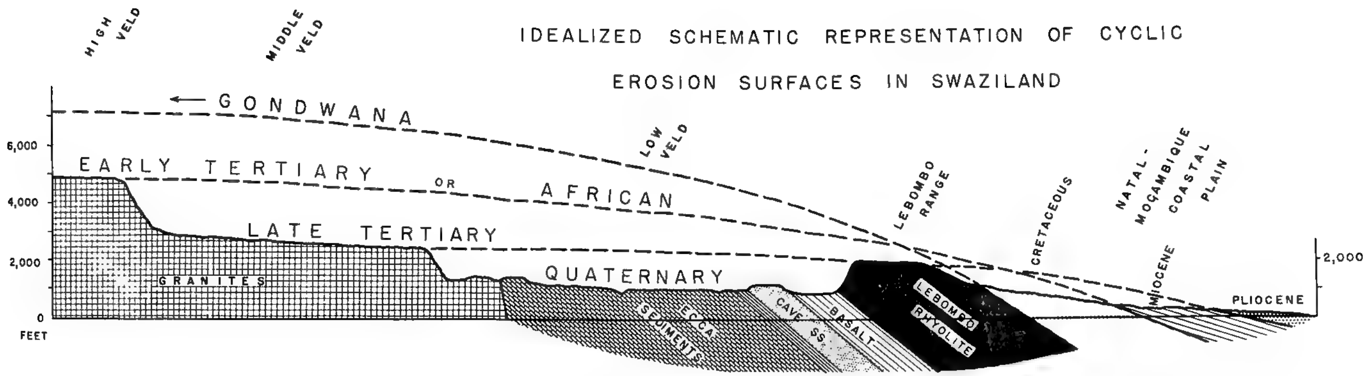
IDEALIZED SCHEMATIC REPRESENTATION OF CYCLIC
EROSION SURFACES IN SWAZILAND
HIGH VELD
MIDDLE VELD
LOW VELD
LEBOMBO RANGE
CRETACEOUS
NATAL-MOÇAMBIQUE COASTAL PLAIN
GONDWANA
EARLY TERTIARY OR AFRICAN
LATE TERTIARY
QUATERNARY
MIOCENE
PLIOCENE
GRANITES
ECCA SEDIMENTS
CAVE SS.
BASALT
LEBOMBO RHYOLITE
6,000
4,000
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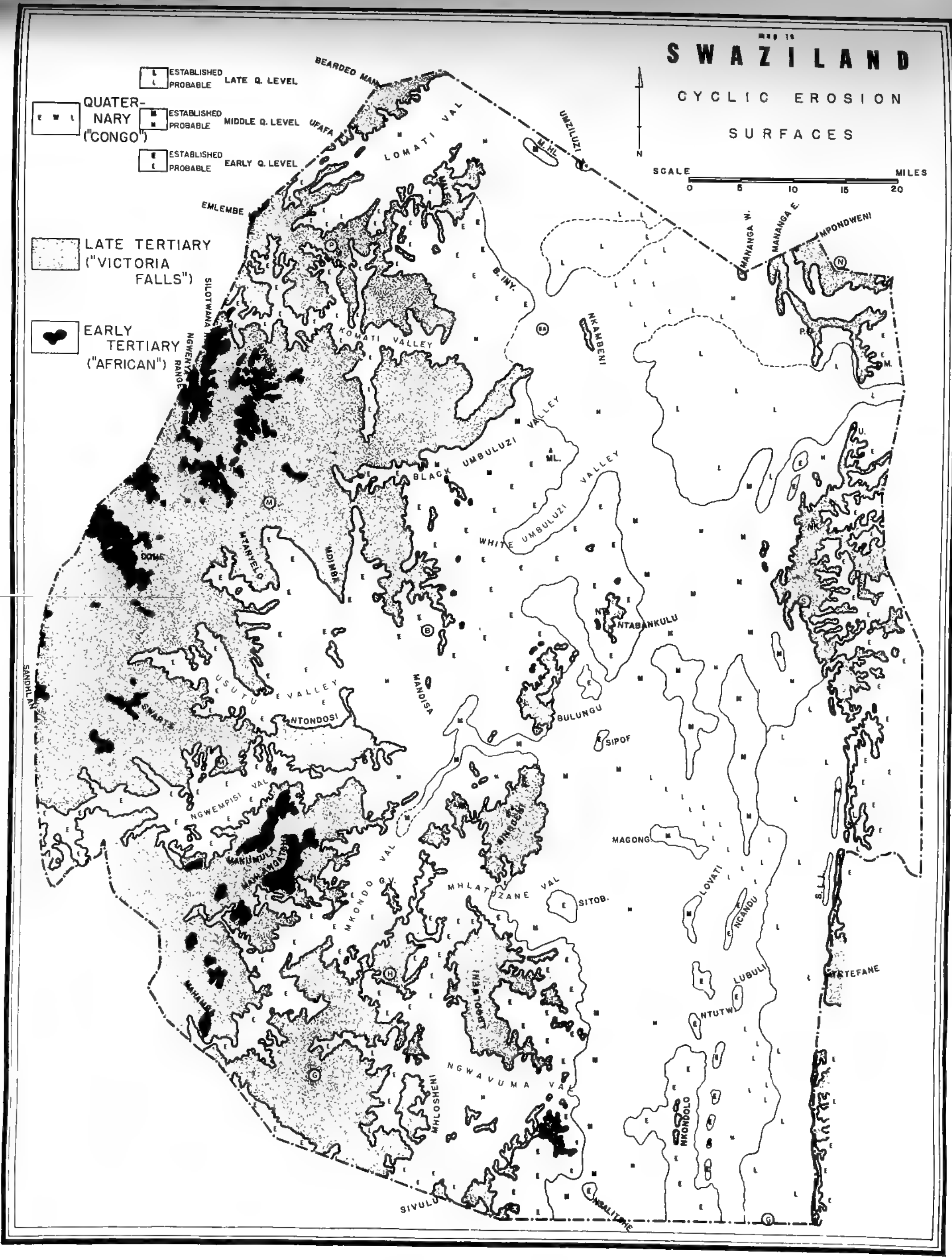
FEET
2,000


SWAZILAND
CYCLIC EROSION
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("CONGO")
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EARLY Q. LEVEL
LATE TERTIARY
("VICTORIA
FALLS")
EARLY
TERTIARY
("AFRICAN")
BEARDED MAN
UFAFA
EMLEMBE
LOMATI VAL
UMZILUZI
M. HL.
MANANGA W.
MANANGA E.
MPONDWENI
SILOTWANA
NGWENYA
RANGE
KOMATI VALLEY
B. INY.
NKAMBENI
BLACK UMBULUZI VALLEY
ML.
WHITE UMBULUZI VALLEY
MTARYELO
MDIMBA
DOME
NTABANKULU
USUTU VALLEY
NTONDOSI
MANDISA
BULUNGU
SIPOF
SANDHLAN
SWARTS
NGWEMPISI VAL
MAGONG
MKONDO GV.
MHLATUZANE VAL
SITOB.
LOVATI
NCANDU
S.L.
LUBULI
NTUTW
LOPOLWENI
MAHAMBA
NGWAVUMA VAL
MHLOSHENI
NKONDOLO
SIVULU
NGALITWE

Lebombo is supported by rhyolites. Beyond the Lebombo lie the Cretaceous, Miocene, Pliocene, and more recent sediments of the Moçambique coastal plain.

A cross section of the relationships between physiography, cyclic erosion surfaces, and general geology produces the sort of imprecise correlation that calls for detailed mapping (Fig. 4). The Gondwana surface is not represented in the Swaziland region except as the unconformity between the Lebombo rhyolite and the oldest (Cretaceous) sedimentaries of the Moçambique coastal plain. The Early Tertiary or African surface still exists in the highveld (Fig. 6, upper), and its aggradational equivalent is in the Cretaceous-Miocene contact and succession. The Late Tertiary or Victoria Falls cycle bevels much of the middleveld, where its elevations are significantly higher (averaging just over 2,500 feet) than on the Lebombo, where remnants of the Late Tertiary lie at 1,800-2,200 feet. The Quaternary surface cuts across sedimentaries and extrusives in the lowveld.

Cartographic representation of the cyclic erosion surfaces of Swaziland reveals a relationship of relief, geology, and geomorphology that is much less close. Very little of the Swaziland highveld, when mapped in detail, proves to support the African pediplain; slope retreat cutting into the Early Tertiary surface has progressed much farther than the step-controlled topography suggests. Indeed, in Swaziland only isolated outliers of the African plateau surface remain (Fig. 6). The highest of these is Emlembe, which at 6,109 feet may be the remnant of an inselberg that stood above the African surface. The degree to which the Late Tertiary surface has been broken by subsequent erosion is similarly noteworthy. In the field, the middleveld appears to extend approximately to a line drawn north-south along the eastern margins of Bulungu and Singceni (see also Fig. 2). But much of the lower middleveld is part of the Quaternary surface; the Late Tertiary surface is already fragmented into numerous erosional outliers. Indeed, the Quater-

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Fig. 2. Relief map of Swaziland.

Fig. 3. Geological map of Swaziland. In part after undated 1:50,000 sheet (unnumbered), Union Geological Survey.

Fig. 4. Idealized section of cyclic erosion surfaces in Swaziland.

Fig. 5. Map of cyclic erosion surfaces in Swaziland.

Fig. 6. Upper photograph. The accordance of ridge summits at 5,000 feet marks the African (Early Tertiary) erosion surface. The photograph was taken across the Mkondo Valley in a northwesterly direction (see Fig. 6). The lowest levels in this photograph are of Quaternary origin; the intermediate surfaces, very small in areal extent, are Late Tertiary.

Fig. 6. Lower photograph. The Late Tertiary bevels the Lebombo Range to a smooth surface. Taken in a northeasterly direction across the Usutu River, this photograph shows one of the sub-levels of the Quaternary erosion surface (A-B).

nary cycle along the Ngwempisi valley has already progressed beyond the western border of Swaziland. In view of this, the survival of the Lebombo section of the Late Tertiary is all the more remarkable, although erosion from the east is now eliminating the remnant surface on the rhyolite. Possible explanations for this situation include (1) the rift hypothesis, which would account for the protection of the Lebombo surface as part of a larger pediplain until quite recently, and (2) the particular quality of hardness of the rhyolite, which is especially reflected in the prominence and persistence of the Lebombo escarpment. Thus the Quaternary surface, which extends over most of Swaziland's territory, may consist of two parts with different origins: the eastern section may have a genesis involving faulting, while the western, digitate section may be purely erosional. In any event, it is possible to recognize more than one bevel within the Quaternary cycle. One such subsurface produces a step-like topography along the Lebombo escarpment just north of the Usutu River gap (Fig. 5, lower).

CONCLUSIONS

Mapping of the cyclic erosion surfaces in Swaziland has led to preliminary conclusions in the following areas: (1) the Early Tertiary or African plateau surface has retreated farther than the region's relief suggests; (2) the Late Tertiary or Victoria Falls cycle in Swaziland and vicinity produced a less effectively beveled surface than the older African cycle or, in this area at least, the younger Quaternary cycle; (3) monoclinal or cymatogenic flexure can be recorded across the pediplains on the middleveld and the Lebombo, and measured perhaps more accurately here than elsewhere in southern Africa; and (4) the Quaternary cycle has penetrated far into the plateau interior along the major river valleys, where it is destroying the Late Tertiary bevels and is even attacking the African surface itself (see Figs. 5 and 6). Clearly a great deal of detailed cartographic work is required before an adequate range of data has been accumulated on the basis of which any representative analysis can be done, but such mapping is now being done. The research here reported was done in the absence of air photographs and, at the time of the field work, only partial contour coverage at a sufficiently large scale. Both air coverage and 1:50,000 contour maps are increasingly available in Africa, and the completion of an

initial large-scale geomorphic map has become possible. This project is a small contribution to that goal.

ACKNOWLEDGMENTS

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Osmotic Equilibration of Marine Algae

T. R. Tosteson, E. Montalvo de Ramirez, and A. Rehm

In an osmotically responsive biological system, the product of the water contents of the system when equilibrated with an external solution of tonicity T_o, and that tonicity, equal a constant. On the basis of an analogy to the ideal gas laws this formulation has been employed to quantify the osmotic relationships between cells and their external media (Harris, 1956; LeFevre, 1964). It is assumed that during the equilibration of the system in question only water moves across the biological membranes separating the external media from the cellular water and that there is a negligible movement of solute. At osmotic equilibrium the tonicity of the external media is assumed to be equal to the tonicity of the cellular water.

Gravimetrically this relationship between the water contents of the equilibrated biological system and the tonicity of the external media may be expressed,

$$(W_o/D)\ T=k$$

where W_o/D are the grams of water per gram dry weight in the biological system, T is the tonicity of the external media with which it is equilibrated, and k is a constant. The total wet weight divided by the dry weight of the biological system may be expressed,

$$W/D=(W_o+W_n+D)\ /D$$

where W/D is the wet weight divided by the dry weight, W_o the grams of osmotically responsive water, W_n the grams of water that do not respond osmotically, and D the dry weight (gm) of the biological material. Rearranging the second expression,

$$W_o/D=W/D-\ (W_n+D)\ /D$$

By substitution into the first expression and rearrangement,

$$W/D=k/T+(W_n+D)\ /D$$

Thus the relationship between W/D and 1/T should be a straight line, with an intercept equal to $(W_n+D)\ /D$ and a slope k, related to W_o/D (Tosteson, 1964).

In plant cells the presence of the cell wall permits the development of a pressure (turgor pressure) on the internal solution that in effect increases the "activity" of the water in the vacuole and

protoplasm of this cell type. Thus at osmotic equilibrium with an external solution, the "apparent" tonicity of the cellular water equals the tonicity of the external medium. However the true tonicity of the cellular water T_c is slightly greater than the tonicity of the external medium with which it "equilibrated" and this difference is balanced by the effect of the turgor pressure (Sutcliffe, 1968). Thus,

$$T_e = T_c - (\triangle T)$$

where $(\triangle T)$ is the effective reduction in the true tonicity of the cellular water caused by the existence of turgor pressure. In other terms the "activity" of the water in the cell at osmotic equilibrium is slightly less than that of the water in the external media. This effect is cancelled by the presence of the turgor pressure which effectively increases the "activity" of the cellular water. In the work to be reported here the symbol T connotes the tonicity of the external solution with which the cells equilibrate, and equals the "effective" tonicity of the cellular water, that is the true tonicity minus the effect of the turgor pressure.

The turgor pressure has been shown in a number of algae to remain constant over a fairly wide range of environmental tonicities. Recently it has been suggested that the turgor pressure in the walled plant cell is regulated through adjustments in their salt uptake rates (Gutknecht, 1968). While the evaluation of this component in the osmotically equilibrated algal system is of importance no attempt will be made in the work reported here to quantitate this factor.

PROCEDURE

The algae employed in these studies were of three species, *Caulerpa racemosa, Ulva lactuca* and *Spyridia filamentosa.* Samples of each type of algae were collected in the area of the Marine Station at La Parguera and brought directly to the laboratory. These samples were then prepared for experimentation, washed free of extraneous matter and foreign algae with millipore filtered sea water (pore size 0.45 micron) and placed in a large volume of filtered sea water in an illuminated growth chamber at a temperature of 28-29 C. In the case of each type of algae, selected portions and/or entire plants were then placed in a series of sea water solutions of

varying tonicities. In the experiments performed with *Ulva* and *Spyridia* several individual plants were placed in each of the various experimental solutions. The preparation of the material to be used in the experiments with *Caulerpa* (var. *laetevirens*) involved the separation of the assimilator from its rhizome. In the area of the connection to its rhizome the assimilator was twisted and pinched. A period of from 5-10 minutes was allowed for the formation of new crosswalls, following which the assimilator was cut from the rhizome. These isolated assimilators were placed in a constant flow aquarium for 12 hours prior to experimentation. The assimilators employed were examined visually for damage prior to their use. The index of damage in this case was the appearance of discoloration.

The three to four experimental tonicities employed in each experiment generally varied from two-thirds that of normal sea water to 1 1/3. The hypotonic sea water solutions were prepared by the addition of distilled water to the sea water and the hypertonic solutions by the addition of NaCl. All solutions were filtered through millipore filters (pore size 0.45 micron) prior to their use. The algae were exposed to these altered tonicities for varying lengths of time (from 1-24 hours) in the illuminated growth chamber. At the conclusion of a given experiment (of a given duration) each of the samples that were exposed to each of the tonicities in question was weighed. Following the determination of the wet weight of the sample in each case, the algae were dried either in an oven (105-110 C) to a constant dry weight (2 hours) or using the Ohaus Drying Balance at temperatures of 110-111 C. The latter procedure was employed with the *Ulva* and *Spyridia* samples and the former was employed with the samples of *Caulerpa*. In the procedure utilizing the Ohaus Drying Balance, constant dry weights were obtained in general after 25-30 minutes. The dry weight of the samples of *Caulerpa* were determined on an analytical balance.

Thus in the case of each algal sample exposed to a set of different tonicities for a given length of time, the quantity W/D was determined. The solutions in which these samples were equilibrated were individually filtered through millipore filters (pore size 0.45 micron) following the experimental incubation time. The tonicities of those solutions were then determined with the Fiske Freezing Point Depression Osmometer. The volume of solution employed in

the incubation of the samples in question was kept large (150-250 ml) compared to the volume of plant material incubated. The tonicity of the external media with which the algae equilibrated in such a case essentially remained constant, suggesting the absence of or at least rendering osmotically insignificant any changes in the solute distribution within the system.

The equilibration of the algae in question was studied over a period of from 18-24 hours, illuminated and at the temperature cited above. For each set of tonicities at a given incubation time, the relationship between the quantities W/D and 1/T was determined. In each case the value of W/D at isotonicity ((W/D) iso) was determined. Isotonicity in the *Caulerpa* experiments was 1,043 milliosmols/kg water ($(1/T) \times 10^3 = 0.959$) and in the case of the *Ulva* and *Spyridia* experiments 1, 026 milliosmols/kg water ($(1/T \times 10^3 = 0.975)$. The value (W/D) iso $- 1 = (W_o + W_n)/D$, the isotonic water content in grams water/gram dry weight of the algal sample in question. The intercept of the relation between W/D and 1/T at a value of $1/T = 0$, gives the value of $(W_n + D)/D$. The value of (W/D) iso $-$ intercept $= W_o/D$, the grams of water osmotically responsive in the plant tissue per gram dry weight of that tissue. The fraction of the total isotonic water content that is osmotically responsive can thus be calculated, $W_o/(W_o + W_n)$. These parameters, the total isotonic water content of the plant tissue and the fraction of that water osmotically responsive were followed as a function of equilibration time in the three types of algae employed in this study.

The survival of the algal samples employed in these studies was determined by employing duplicate sets of tissues in each incubation medium used in each experiment. One of these tissues was used to determine the equilibrated W/D and the other was employed to test the viability of the sample after the completion of the experimental incubation period. The *Caulerpa* samples used to assess survival were removed from their respective incubation medias and placed in a continuous flow sea water aquarium at ambient light and temperature conditions for seven days. Discoloration was used as an index of death in this case.

Samples of *Ulva* and *Spyridia* were tested for survival after being exposed to the experimental conditions outlined above by placing treated samples in small wire baskets which were then

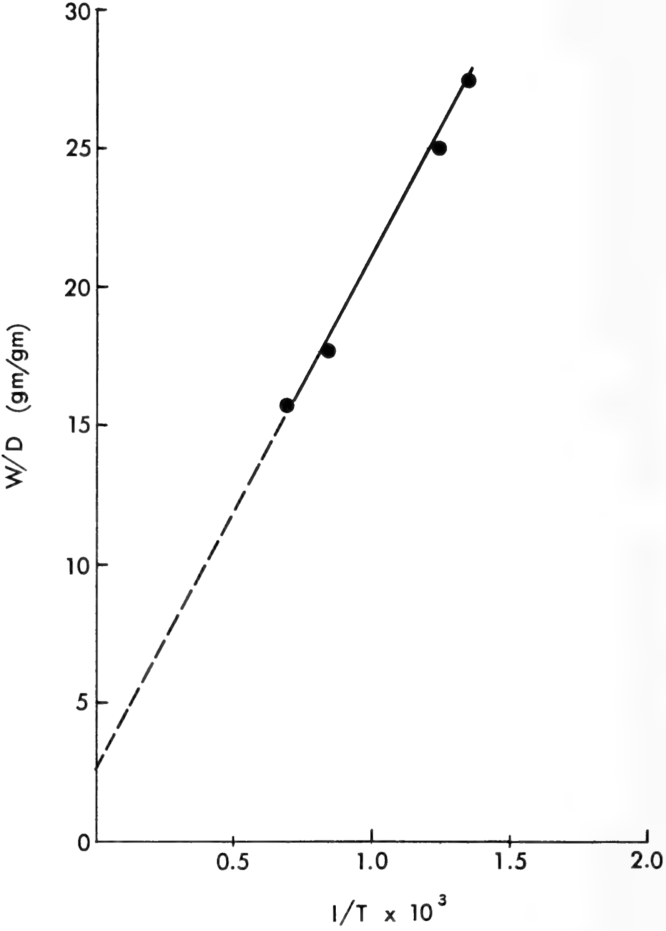

Fig. 1. Relationship between quantities W/D and 1/T for an equilibration experiment with *Caulerpa racemosa*.

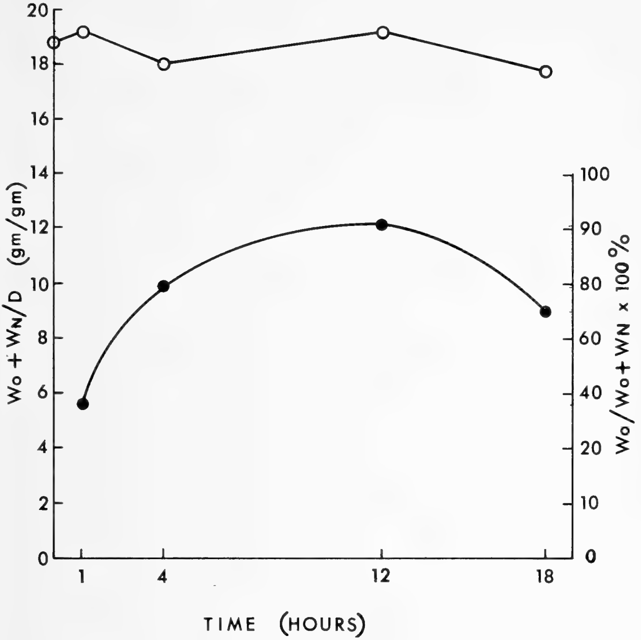

Fig. 2. Change in quantities W/D and 1/T as a function of time, in a series of six experiments with *Caulerpa racemosa.*

placed in the sea in the area of the marine station at La Parguera. Seven days later these samples were examined. Disintegration and discoloration were taken as an index of death.

RESULTS

Caulerpa racemosa. The range of tonicities employed in the experiments reported here was from 1,349 milliosmols/kg water on the hypertonic side to a hypotonicity of 733 milliosmols/kg water. Figure 1 illustrates the relationship between the quantities W/D and 1/T for one of the equilibration experiments with *Caulerpa.* The demonstrated linearity in the relationship of W/D to 1/T was found

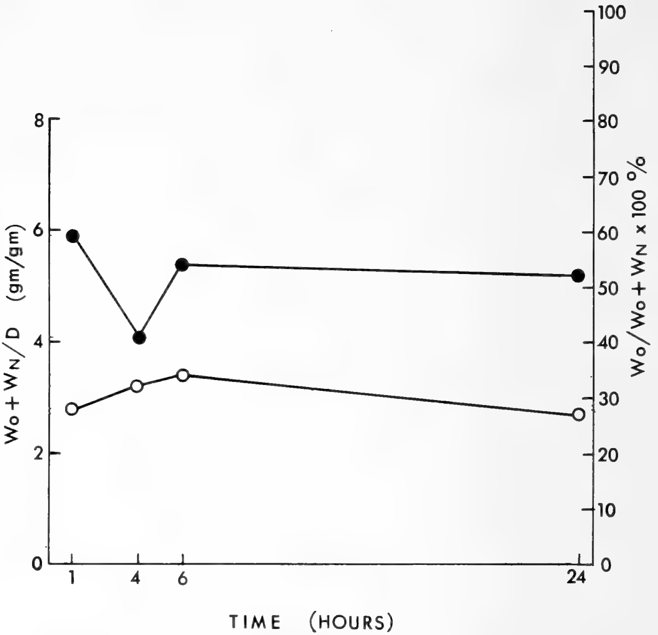

Fig. 3. Results of 10 equilibration experiments with *Ulva lactuca.*

to be true in all of the experiments with this alga. A similar linearity was found in the case of the experiments utilizing the algae *Ulva lactuca* and *Spyridia filamentosa.* On the basis of the linear regressions, computed by the method of least squares, the isotonic W/D and hence the isotonic water content ((W_o+W_n) /D) and the fraction of that water osmotically responsive ($W_o/(W_o+W_n)$) were ascertained for each time of incubation (equilibration).

Figure 2 illustrates the change in these quantities as a function of time, in a series of six representative experiments with *Caulerpa.* The isotonic water contents of the assimilators of *Caulerpa* do not appear to change markedly with time of incubation. On the other hand the fraction of the water osmotically responsive appears to in-

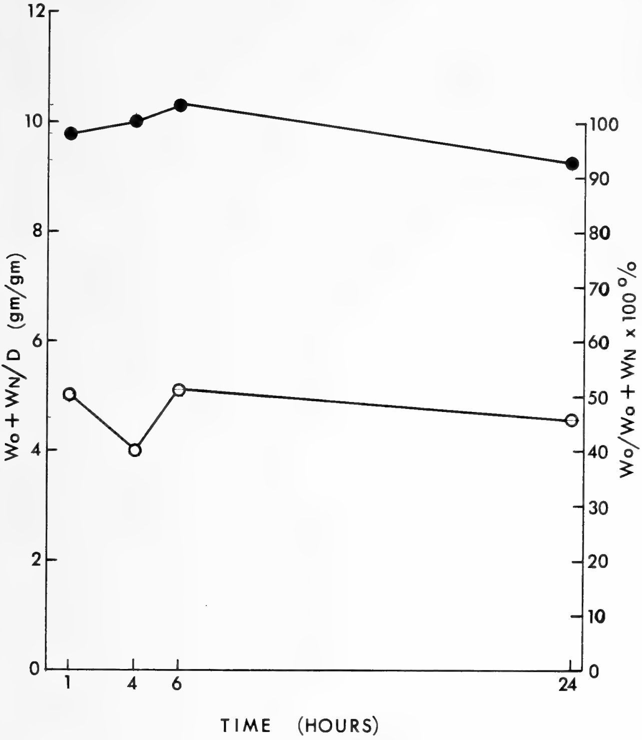

Fig. 4. Results of seven equilibration experiments with *Spyridia filamentosa.*

crease to a value as high as 91 per cent in 12 hours of equilibration. This fraction decreases however in experiments of 18 hours duration. Thus while the linearity of the relation between W/D and 1/T is found at each of the incubation times, suggesting an osmotic equilibration, the water contents of the tissue appear to continue to alter. The isotonic water contents appear to stay constant (avg. 18.971 gm of water/gram dry weight), however, the quantity of water osmotically responsive increases with time up to 12 hours. Following this, $W_o/(W_o+W_n)$ decreases in value.

The results of the survival determinations in the case of this alga, indicate that all of the experimentally treated samples survived up through 12 hours of incubation. After 18 hours of incubation only samples kept in isotonic sea water solutions survived and all those samples placed in altered tonicities (hypertonic or hypotonic) were no longer viable. Thus even variations in tonicity of ±226 mosmols from isotonicity, were deliterious to the survival of the assimilators after 18 hours of equilibration.

Ulva lactura. The results of 10 representative equilibration experiments with this alga are given in Fig. 3. In this graph the average figures for the parameters defined previously are given as a function of time of equilibration. The average isotonic water content (±SD) of *Ulva* is 5.097 ±.769 gm H_2O/gm dry weight. This parameter and the average fraction of water osmotically responsive (average 30.75 ±2.75 per cent) appear to be independent of the time of equilibration up to 24 hours. All samples of *Ulva lactuca* equilibrated over periods up to 24 hours (Fig. 3) survived the experimental conditions described.

Spyridia filamentosa. Figure 4 gives the results of the equilibration of this alga over periods up to 24 hours. There were seven equilibration experiments carried out in this case. The average isotonic water content of *Spyridia* is 9.85 ± .425 gm H_2O/gm dry weight. The average fraction of this total water osmotically responsive was 46.82 ± 5.08 per cent. These parameters appear to be independent of the time of equilibration up to 24 hours. Evaluation of the survival of this alga revealed that the samples survived all experimental conditions and equilibration times.

DISCUSSION

The isotonic water contents of the algae used in these experiments varied considerably, from *Caulerpa* (18.971 gm/gm) to *Ulva* (5.097) gm/gm). All samples of algae appeared to initially equilibrate for the relation of W/D *versus* 1/T was essentially linear in each case. However only in the cases of *Spyridia* and *Ulva* were the algae able to maintain themselves in their equilibrated state for periods of time up to 24 hours. The samples of *Caulerpa* did not maintain themselves at the experimental tonicities employed. Thus the slope of the relationship between W/D and 1/T in this case was not independent of time. That this change represents an alteration

in the system which ultimately results in an irreversible damage is supported by the fact that *Caulerpa* does not survive 18 hours of equilibration whereas both *Ulva* and *Spyridia* do. This difference might be attributed to the complexities encountered in the preparation of the *Caulerpa* assimilators for the experiments described. However these assimilators prepared in the fashion described, isolated from their rhizomes, do survive and resume growth when exposed to ambient conditions. Those samples exposed to isotonic sea water in the experiments reported here also survive. Thus the experimental procedures do not appear to account entirely for the response of this alga to altered tonicities, for if there had been fundamental damage incurred in preparing the assimilators it is doubtful that those samples incubated in isotonic media or sea water in ambient conditions, would have been able to maintain their isotonic water content or survive.

The *Caulerpa* tissues exposed to hypotonic conditions slowly continued to gain water whereas those exposed to hypertonic conditions slowly continued to lose water. Thus the slope of the relation between W/D and 1/T continues to change (becomes greater) in time. These losses and gains of water are not reflected in changes in the total isotonic water contents of the plant tissue in time, but rather are reflected in the water contents of the osmotically responsive compartment exposed to an altered tonicity. Thus the *Caulerpa* assimilators do not appear to be able to equilibrate in the strict sense of the word. Following 12 hours of incubation the osmotic compartment exposed to hypotonic conditions begins to *lose* water, whereas in hypertonic conditions it begins to *gain* water (the slope of W/D vs. 1/T decreases). Such a condition would result if the respective compartments were to lose and gain salt. This condition suggests a marked change in the permeability of the membranes involved. At the equilibration time of 12 hours, 91 per cent of the isotonic water contents of this material are in the osmotically responsive compartment. The presence of a large quantity of water within this compartment suggests a considerable strain on the plasticity of the membrane components involved. Thus it is possible that a severely damaged or broken membrane might result from the swollen (or shrunken) osmotic component of a cell unable to equilibrate in a given tonicity. The decrease in the slope of W/D vs. 1/T after 12 hours of equilibration in the *Caulerpa*

samples suggests a sharp change in the permeability of the membrane enclosing the osmotically responsive compartment.

The results with the samples of *Ulva* and *Spyridia* indicate the ability of these algae to equilibrate and maintain themselves in the experimental conditions employed. The size of the osmotically responsive compartment in terms of its water content appears to be larger in the case of *Spyridia.*

In all three of the algae utilized in these experiments, in *Caulerpa* initially and in *Ulva* and *Spyridia* at osmotic equilibrium, a rather large fraction of the total isotonic water content of the plant is found to be osmotically unresponsive (W_n/D). In the case of the equilibrating algae, *Ulva* and *Spyridia,* approximately 60-70 per cent of the total isotonic water content appears to be either associated with a tissue compartment that does not respond osmotically or represents water structurally immobilized. Tissue water in the former case can be viewed as being associated with tissue spaces not delimited by a living membrane whereas in the former case this water would be "bound" to intercellular structure in such a manner as to prevent its responding to an osmotic gradient. While the latter case seems unlikely, as a result of the quantity of water involved, determinations of the true "extracellular space" in the plant tissues employed in these experiments were not made. The definition of the nature of this high fraction of osmotically un-responsive water in *Ulva* and *Spyridia* bears further experimentation. Such work is now in progress in this laboratory.

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Occurrence of *Brevoortia gunteri* in Mississippi Sound

William R. Turner

Three species of menhaden and one hybrid are currently recognized from the Gulf of Mexico. The most abundant species, Gulf menhaden, *Brevoortia patronus*, ranges from the Caloosahatchee River in southwest Florida (Christmas and Gunter, 1960) to the Yucatan peninsula in Mexico (Reintjes and June, 1961). The yellowfin menhaden, *B. smithi*, occurs in the Gulf from Florida Bay to the Mississippi Delta (Reintjes and June, 1961). Hybrid menhaden occur over part of the range where these two species overlap. *B. smithi* × *patronus* have been collected offshore from Tampa Bay south to Cape Sable, Florida (Turner, 1969). Dahlberg (1966), who originally described the hybrids, recorded them from as far north as Port St. Joe along the west coast of Florida. The finescale menhaden, *B. gunteri*, occurs from Louisiana to the Gulf of Campeche in Mexico; the easternmost previous record is Chandeleur Sound NW of North Island, Louisiana (Christmas and Gunter, 1960).

The collection on 29 October 1966 of a finescale menhaden in a haul seine at Pascagoula Beach, Mississippi, extended the known range of the species eastward by approximately 35 miles and constitutes the first record from Mississippi Sound. The specimen, a 278 mm (fork length) mature male (Beaufort Biological Laboratory Catalog No. BL 955), was identified by the vertebral count (43, including the urostyle), which corresponded to the modal count obtained by Hildebrand (1948) and readily distinguished the fish from *B. smithi*, (the only other fine-scaled species of North American menhadens) which has 45 to 47 vertebrae. (*B. smithi* and *B. gunteri*, characterized by small scales, are frequently grouped as fine-scaled menhadens; *B. patronus* has larger scales and together with its cognate, *B. tyrannus*, along the Atlantic States composes the coarse-scaled menhadens).

The occurrence of *B. gunteri* in Mississippi Sound in late October represented an extension in time as well as range for this species in the northern Gulf. The latest date of collection previously recorded for finescale menhaden in waters of the northern Gulf was on 30 September (Christmas and Gunter, 1960). The October col-

lection was significant because it coincided with the time Suttkus (1956) inferred *B. patronus* began spawning in that region, and the specimen was categorized as stage III, ripening (as defined by Turner, 1969). Although this record establishes the occurrence of mature *B. gunteri* along the northern Gulf coast at the onset of the menhaden spawning season, young finescale menhaden have never been recognized in collections of juveniles from estuarine waters in that region. Hybrids between *B. gunteri* and the other two sympatric menhadens are unknown.

ACKNOWLEDGMENT

I wish to thank Mr. Hilton M. Floyd of the Bureau of Commercial Fisheries Exploratory Fishing and Gear Research Base, Pascagoula, Mississippi, who collected and donated the specimen to the Beaufort Biological Laboratory.

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Reproduction of the Clingfish, *Gobiesox strumosus*

Robert A. Martin and Catharine L. Martin

The early development of the clingfish, *Gobiesox strumosus* Cope, was studied in some detail by Runyan (1962), but data concerning reproductive behavior, successive spawnings, and possible reproductive potential, were not included. Comparative figures are lacking on the developmental rate of embryos under differing conditions.

Materials and Methods

The breeding pair (male 69 mm, female 41 mm SL) were collected with a hand net on a concrete groin at 1400 Gulf Blvd., Madeira Beach, Florida. The initial spawning occurred in a 30 gallon plexiglass community tank on September 25, 1966. Eggs were attached in an oval cluster on the wall facing the laboratory window. An estimated 30 eggs were eaten by other fishes before parents and eggs could be segregated from them by inserting a glass partition. On September 27, a second clutch was attached next to the first.

After the second spawning, parents were transferred to a separate 20 gallon epoxy-plywood tank with submersible bone-charcoal filter and artificial breeding chamber. Spawning occurred in this tank on the following dates: 4 Oct. 1966, 20 Oct., 29-30 Oct., 7 Nov., 10 Nov., 17 Nov., 26 Nov., 30 Nov., 14 Dec. No attempt was made to raise the fry, though they survived 3-5 days after hatching. Eggs and embryos were examined live and subsequently preserved in a neutralized 10 per cent formalin solution for later reference.

The breeding chamber consisted of a 125 mm section of 50 mm PVC pipe cemented along the long axis to a rectangular base, and sealed at one end with a plastic disc. A single sheet of 125 $\times$ 75 mm photographic film cleared after exposure to light was inserted to line the roof of the breeding chamber. Eggs were subsequently attached to this sheet, which could be removed for examination without disturbing the male guardian. Small strips of film with attached eggs were trimmed from this sheet at regular intervals for inspection and preservation.

Pre-Spawning Activity

Events prior to the third spawning on October 4, 1966, passed through four distinct phases (1) exploration of the new tank and

breeding chamber by the pair, (2) adoption of the chamber by the male, (3) activity by the male to entice the female to this chamber, (4) acceptance of the male and his chosen site by the female. Both fishes made periodic explorations of their new tank which included two coral rocks, filter, and breeding chamber.

On the day prior to spawning, the male centered his activity in and about the breeding chamber, while the female tended to favor the aquarium wall closest to the laboratory window. By the following day the female tended to position herself much closer to the chamber on the same wall about 3 inches from the bottom. The male moved in and out of the chamber several times passing in static jerks upside down along the ceiling, then up over the rim, thus landing right side up on the roof where he faced his mate.

Though the female gave no obvious response to the male's display, he attached next to her on the wall and pressed close to her side. Both fishes faced the surface for a few seconds undulating their tails in unison with their genital papillae closely aligned, after which the male appeared to rotate his mate from her vertical position to one paralleling the bottom. When he returned to the spawning site the female followed. After the male had entered and left the breeding chamber the female entered alone, but when he attempted to join her, she quickly emerged. This avoidance pattern was repeated several times before the female remained with the male and spawning began.

SPAWNING ACTIVITY

The second spawning, which occurred while the pair was still in the plexiglass tank afforded the only opportunity to observe the details of egg deposition. The female faced upward during oviposition, and deposited the eggs from bottom to top in vertical rows attached to the wall of the tank. During the early stages of this activity the male vigorously undulated alongside the female, but later deserted her for increasing periods to pass over other parts of the growing egg mass. Both fishes rested for short periods during spawning. Milt was not observed.

Eggs were extruded individually at 2-5 second intervals during the period of observation which was from 1540-1650 hr. Approximately one-fourth of the eggs were deposited during this time. No infertile eggs were found in this mass.

TABLE 1

Developmental time, in hours, for eggs of *Gobiesox strumosus* reared at four different temperature ranges. Stages are those of Lagler, Bardach and Miller (1962)

Stage	Cluster 3*	Cluster 4	Cluster 8	Cluster 9
13			19	
14	24		24	
16			43	
17			51	
19	42	42		50
20		64	70	
22	67	72	94	98
24	72	91	99	98
26	92	96		
27			115	
28	120			
30			139	
31		113		122
32		120	163	174
33		162	187	
34		216	211	
35		258		
36		306		

*Cluster 3 (26.1-28.3C) cluster 4 (23.9-26.1C), cluster 8 (22.7-22.8C), cluster 9 (20-21.1C).

Spawning activity was confined to the daylight hours (0730-1900), with nine spawnings initiated between 1530 and 1830 hours. One egg mass (29-30 Oct.) was interrupted and not completed until the following morning. The breeding tank was not provided with special lighting, and ceiling lights were usually turned off by 1800 hours. Varying chemical and physical conditions were: *p*H 7.5-7.9; salinity 27-30 o/oo; water temperature 20-28.3 C.

Fertilization appeared to be complete in all cases. Five eggs did not hatch in batch 5 (29-30 Oct.) because of fungus. No more than two or three failed to hatch in each of the other clusters. One two-headed embryo almost reached the hatching stage in the tenth cluster (30 Nov.). Egg sizes agreed with those reported by Runyan (1962).

EGG TALLIES

The first two egg masses were tallied by means of marked photographs. Subsequent figures represent visual estimates based on

the size and density of the egg clutch. Tallies for eleven successive spawnings were: 1,126, 756, 350, 350, 700, 1,000, 300, 600, 600, 1,000, and 350. The conservative total is 7,100.

During the incubation period, the male guarded, regularly brushed and fanned the eggs, but showed no further interest after they hatched. The female took no part in egg care.

EARLY DEVELOPMENT

Hatching occurred in 5-7 days with eggs in the same clutch generally hatching within a 10 hr period. Time required for embryonic development tended to increase as water temperatures fell below 23.9 C. Numbers cited for developmental stages (Table 1) refer to those of Lagler et al. (1962) for *Fundulus heteroclitus*.

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Recent Coyote Record from Florida

Vernon D. Cunningham and Robert D. Dunford

Coyotes (*Canis latrans*) have previously been reported in Florida. Young and Jackson (1951) mention releases as early as 1925 when four coyotes were liberated in Palm Beach County and 10 were set free near Arcadia in DeSoto County. Also in 1930-31, 16 more were released in DeSoto County. Young and Jackson report coyotes killed in Collier County and on Key Largo, Monroe County, and seven miles east of Sparr, Marion County. Lacking are recent records of adult breeding coyotes in Florida.

On May 28, 1969 two coyote pups were dug out of a den seven miles northeast of Lake Wales in Polk County Florida. Two adults, one male and one female, were trapped approximately 400 yards from the den on June 15. These animals were determined to be coyotes using criteria developed by Howard (1949). These coyotes are probably descendants of those brought into the area in the early 1950's by hound enthusiasts as quarry for the dogs (personal communication).

Complete measurements were taken on the two adult coyotes, and the skins and skulls are now in the Florida State Museum, University of Florida, Gainesville, Florida. Measurements on the male (UF 8631) and female (UF 8630) respectively are as follows (mm): total length, 1199, 1188; tail length, 345.0, 344.0; hind foot, 203.0, 190.0; nose pad diameter, 27.7, 24.5; weight, 17.4 kg, 12.0 kg. Skull measurements (mm) are: condylobasal length, 195.0, 174.5; palatal length, 98.2, 90.6; palatal width, 21.0, 20.8; squamosal constriction, 64.2, 60.7; zygomatic breadth, 108.2, 96.0; interorbital breadth, 39.7, 33.0; maxillary tooth-row, 93.0, 82.7; upper molar tooth-row, 74.9, 68.9; upper carnassial length, 20.9, 17.2; first upper molar length, 13.1, 12.8; first upper molar breadth, 18.6, 17.0; lower carnassial length, 22.7, 21.5; canine diameter at base 10.4, 9.0.

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Herpetofauna of Dauphin Island, Alabama

Crawford G. Jackson, Jr., and Marguerite M. Jackson

Dauphin Island lies in the Gulf of Mexico about 4.5 nautical miles off the southern coast of Mobile County, Alabama. The island, oriented in an east-west direction, is about 12 nautical miles long and the width varies from less than a mile to about 2 miles. The parallel 30°7′30″ north latitude and the meridian 88°11′30″ west longitude intersect at about the center of the island. It is separated from the mainland by Mississippi Sound of Recent origin and is a fairly typical long, narrow, dune-bearing barrier island (Longwell et al., 1948). The adjacent mainland shore is a more or less broad fringe of salt and brackish marsh. The island lies within the Austroriparian Biotic Province (Dice, 1943), and Chermock (1952) places it in the Saballian Life Zone. It is low and sandy, with no point reaching 50 feet elevation above mean sea level. The western half is quite narrow, with the windward beach grading into low sand dunes. The leeward shore of this area is covered with marsh grass, and contains numerous tide pools which communicate with Mississippi Sound during high tide.

The eastern half of the island possesses high dunes on the windward shore which offer protection to the interior pine flatwoods and freshwater marsh communities.

Few permanent residents inhabit Dauphin Island. During the summer, numbers of people utilize the island for recreational purposes. Prior to the building of an overwater bridge in 1955, the area could be reached only by boat. Development of the land with attendant habitat alterations has been rather slow. Consequently, it appears the herpetofauna has not been unduly influenced as yet.

Concerted efforts by local and national conservationist groups resulted in the setting aside of a 164 acre tract in the eastern end of the island as a wildlife refuge. In 1961, a 10 acre permanent lake was created in the natural freshwater marsh of the tract (Gaillard, 1968).

Slash pine (*Pinus elliotti*) is the dominant tree of the inner dunes and pine flatwoods of the eastern half of the island. Live oaks (*Quercus virginiana*) are abundant, and a number of large individuals occur on the island. The dominant tree of the fresh-

water marsh is black gum (*Nyssa biflora*). The western half of the island is essentially treeless.

Methods

From May 1966 to August 1967, the writers observed and collected representative specimens of amphibians and reptiles on the island. All specimens collected were deposited in the University of South Alabama Collections. An attempt was made to locate all existing specimens in other collections in order that as complete a faunal list and directory of specimens as possible could be compiled for this report. Collection dates go back as far as 1953. Museum collection designations are as follows: Auburn University (AUM), University of Alabama (UA) University of Southern Mississippi (USM), University of South Alabama (USA). We are grateful to Drs. Robert Mount, Herbert Boschung, William Cliburn and Prof. Floyd Scott, respective curators of these collections, for their assistance and information.

Annotated List

The following list of 13 species of amphibians and 23 species of reptiles includes all forms known from the island to the best of our knowledge.

Usage of vernacular names follows that of Conant (1958). Scientific names are in accordance with Blair et al. (1968) and Conant (1958):

Amphibia

Ambystoma talpoideum (Holbrook). AUM 15552. The mole salamander is not abundant. No adults ever collected from island, although sixteen large larvae are in Auburn collections.

Ambystoma tigrinum tigrinum (Green). AUM 15553. The eastern tiger salamander is not abundant. Seven larvae, but no adults, have been collected.

Amphiuma means means Garden. UA 65-3371. The two-toed amphiuma is apparently rare. Collecting efforts have yielded only one specimen.

Notopthalmus viridescens louisianensis (Wolterstorff). UA 65-3323. The central newt is rare. One specimen known from the island.

Gastrophryne carolinensis (Holbrook). UA 65-29 to 65-31. Additional specimens of the eastern narrow-mouthed toad are in the Auburn collections. We have heard breeding choruses in the sanctuary swamp.

Scaphiopus holbrooki (Harlan). USA 1147 to 1169; 1441. The eastern spadefoot is sporadically abundant. Additional specimens in the Auburn collections.

Bufo quercicus Holbrook. UA 65-848 to 65-856. The oak toad is not common.

Bufo terrestris (Bonnaterre). USA 1420 to 1431. The southern toad is probably the most common amphibian on the island. A large series also in University of Alabama collections. Individuals may be frequently encountered which are near maximum size given by Conant (1958).

Hyla cinerea cinerea (Schneider). The green treefrog has not yet been collected from the island. We heard a single individual calling from the dense vegetation for several hours during the evening of 4 August 1966 from a roadside ditch, but were unable to collect it. Very abundant on mainland adjacent to island.

Hyla crucifer crucifer Wied. The northern spring peeper has not yet been collected. A single chorus heard calling from dense vegetation bordering roadside ditch during evening of rainy weather on 5 August 1966, but we were unable to collect any specimens.

Hyla squirella Latreille. USA 1092 to 1096; 1436 to 1440. The squirrel treefrog is quite common and the second most abundant amphibian on the island. Additional specimens are in the Auburn collections.

Rana grylio Stejneger. USA 1432. The pig frog is moderately common, particularly in emergent vegetation of the sanctuary lake. Additional specimens in the Auburn collections.

Rana pipiens sphenocephala Cope. USA 1433 to 1435. The southern leopard frog is moderately common, especially in the roadside ditches where it breeds. Additional specimens in the Auburn collections.

REPTILIA

Kinosternon subrubrum subrubrum (Lacépède) × *K. s. hippocrepis* Gray. USA 870; 1415 to 1417. The population is an inter-

grade one between *K. s. subrubrum* and *K. s. hippocrepis.* Mud turtles are fairly common and the most abundant chelonians present. Additional specimens are in the University of Alabama collections.

Deirochelys reticularia reticularia (Latreille). USA 74; 1413 to 1414. The eastern chicken turtle is not rare.

Malaclemys terrapin pileata (Wied). USA 1418 to 1419. The Mississippi diamondback terrapin is not rare, but mostly confined to the western half of the island. Additional specimens in the Auburn collections.

Pseudemys alabamensis Baur. USA 1253. The Alabama red-bellied turtle is undoubtedly not an established resident of the island. One waif individual known.

Terrapene carolina major (Agassiz). USA 80 and 125. The gulf coast box turtle is very rare. Known only from a pair of large males which one of us (CGJ, Jr.) observed fighting on 18 June 1966 and subsequently collected.

Caretta caretta caretta (Linnaeus). USA 1396 and 1412. The Atlantic loggerhead regularly nests on the southern seaward beaches of the island.

Alligator mississippiensis (Daudin). The American alligator is rare. Dr. Wilson Gaillard informs us (personal communication) that a 9 foot individual was captured during excavation for the sanctuary lake in 1961, while a similar sized individual eluded capture. He has seen several smaller ones at various times since then.

Anolis carolinensis Voight. USA 1405 to 1406. The green anole is common. Additional specimens in the Auburn and University of Alabama collections.

Sceloporus undulatus undulatus (Latreille). UA 66-246 to 66-247. The southern fence lizard is not common.

Ophisaurus ventralis (Linneaus). USA 1411. The eastern glass lizard is not uncommon. Additional specimens in the University of Alabama collections.

Cnemidophorus sexlineatus (Linneaus). UA 66-110 to 66-118. The six-lined racerunner is fairly common in the dunes area adjacent to the sanctuary.

Eumeces inexpectatus Taylor. USA 1407 to 1408. The southeastern five-lined skink is rare.

Lygosoma laterale Say. USA 155; 1409 to 1410. The ground

skink is quite common. The most abundant lizard on the island. Additional specimens in the University of Alabama and Auburn collections.

Cemophora coccinea (Blumenbach). USA 1401. The scarlet snake is evidently rare.

Coluber constrictor priapus Dunn & Wood. UA 65-3722 to 65-3723; 65-3726. The southern black racer is not common.

Farancia abacura abacura (Holbrook). AUM 867. The only mud snake collected on the island is a juvenile in the Auburn collections. According to Dr. Robert H. Mount (personal communication), this specimen has 70 red bars and is thus easily referable to ssp. *abacura,* as compared to the only *Farancia* in the AUM collections from mainland Mobile County which has 35 bars and is clearly *F. a. reinwardti* (Schlegel).

Heterodon platyrhinos Latreille. USA 198. The eastern hognose snake is either quite rare or possibly not an established species on the island since we have seen it swimming in the brackish water of coastal mainland inlets. The one specimen collected is probably a waif.

Lampropeltis getulus getulus (Linnaeus). UA 53-46 and 65-3795. The eastern kingsnake is not common.

Natrix sipedon clarki (Baird & Girard). USA 1402. The gulf salt marsh snake is the most abundant snake present, although it is mainly confined to the western half of the island. Additional specimens in the Auburn collections and a large series in the University of Southern Mississippi collections.

Rhadinea flavilata (Cope). USA 1403. The yellow-lipped snake is apparently rare.

Tantilla coronata coronata Baird & Girard. USA 1404. The southeastern crowned snake is not common. An additional specimen in the University of Alabama collections.

Thamnophis sauritus (Linnaeus). USM 55-429. The ribbon snake is known only from one specimen collected 9 May 1953. Probably no longer present on island, since this easily observable species would surely have been seen or collected since that time.

Agkistrodon piscivorus leucostoma (Troost). USA 1397 to 1400. The western cottonmouth is not uncommon, and its numbers may be increasing as a result of the creation of the sanctuary.

Remarks

In August of 1969, the track of Hurricane "Camille" (U. S. Weather Bureau designation) passed about 45 nautical miles west of the island. High velocity winds and powerful wave action caused great destruction and habitat disruption. Large trees were uprooted and part of the low western tip of the island was found washed away when the storm had subsided. The violence of this storm may have had an effect on the herpetofauna. In the case of *Natrix s. clarki*, considerable portions of its habitat in the western end of the island were profoundly disrupted or destroyed. Since the present study was completed prior to August 1969, it is hoped that it will be of use in future attempts to assess the effects of hurricane forces on the fauna of the barrier islands.

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Breeding of a Pair of Pen-reared Green Turtles

Ross Witham

The green turtle, *Chelonia mydas* (Linne.), an over-exploited animal of economic importance, has long been of interest to researchers and conservationists. This species has been brought to the point of near extinction and is now rarely found in places where it was once abundant (Ingle and Smith, 1949; Carr, 1952; Carr and Ingle, 1959).

Among the efforts to save these turtles are those of Dr. Archie Carr and his associates who remove newly laid eggs from the beach at Tortuguero, Costa Rica and replant them in the immediate area in man-made nests. After hatching, the young turtles are released into the sea over a wide geographical range. While this may be successful in establishing new breeding places, the small, vulnerable turtles are still heavily preyed upon by various birds and fishes. Moorehouse (1933) suggested that the hatchlings be raised in impoundments. Tagging studies (Witham and Carr, 1969; Carr and Sweat, 1969) indicate that hatchlings held in pens until they are nearly one year old are able to adapt to a natural environment. Although diamond-back terrapins have been bred in captivity (Coker, 1906; Barney, 1922; Hildebrand and Hatzel, 1926; Hildebrand, 1929), there appears to be no mention in the literature of captive sea turtles breeding. The importance of breeding experiments for future farming operations is obvious (Carr, 1969).

Procedures and Discussion

As a part of the turtle conservation project at the House of Refuge Museum on Hutchinson Island, east of Stuart, Florida, efforts were made to hold a few hatchlings to maturity. Copulation by one pair of these pen-reared green turtles and subsequent egg laying are reported.

The female was hatched from a nest found on Hutchinson Island during the summer of 1958 (Carr and Ingle, 1959). Her mate was hatched from eggs shipped from Costa Rica during 1959. On 4 June 1969 the mid-dorsal carapace length (by caliper) of the male was 32.5 inches (825.5 mm); carapace width was 24.5 inches (622.3 mm). The female had a carapace length of 31.5 inches (800.1 mm) and carapace width of 24.0 inches (609.6 mm).

During April of 1968 the turtles were observed attempting to mate. The shallowness of the water in their tank (approximately 2 feet deep) prevented copulation. In the interest of the experiment, Dr. Robert Schroeder offered the use of his facilities in the Florida Keys and the turtles were taken there on 25 April 1968. While there, they were observed mating (Schroeder, personal communication) and thereafter the female crawled twice onto a beach adjacent to the pen. While on shore she made no effort to dig a nest. However, it has been suggested that eggs laid during a particular season were probably fertilized during a previous season (Carr and Giovannoli, 1957). The turtles were returned to the House of Refuge on 5 August 1968.

On the evening of 2 June 1969, approximately one year after mating, the female began laying eggs in the water. All eggs were recovered and immediately washed with fresh water. Of the 24 eggs recovered, 12 were normal (Ingle and Smith, 1949; Carr, 1952), measuring approximately 44 mm, and the others were undersized or malformed. Thirty-one eggs were laid on 2 July 1969 and 6 of these were normal. An additional 28 eggs, 7 of which were normal, were laid on 8 July 1969. The last eggs recovered were 24 laid on 1 August 1969 and only 10 of these were normal. Carr (1952) reported that young terrapins, *Malaclemeys terrapin terrapin* (Schoepff), produce fewer eggs than older ones. It is possible that this is also a factor in the small size of these clutches.

Twenty-four of the normal eggs (11 from the June 2 clutch, 6 from the July 2 clutch, and 7 from the July 8 clutch) were put into boxes of sand; none of these eggs hatched. This was probably due to the deleterious effects of immersion in seawater.

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cilities at Islamorada, Florida. The Martin County Board of Commissioners and the Martin County Historical Society are due special thanks for maintaining the facilities at the House of Refuge Museum. Mating efforts of the turtles were first observed by Mr. William Alloway of the museum staff, and Mr. and Mrs. Steve Bishop, also of the staff, observed the egg layings and recovered the eggs.

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The Possible Evolutionary History of two Florida Skinks

Steven P. Christman

Telford (1962) listed the known locality records for the endemic sand skink, *Neoseps reynoldsi* Stejneger. He reported 15 localities within Highlands, Polk and Lake counties as valid, and discounted the Alachua and Dade county records (Telford, 1959, 1962).

During the past 6 months five specimens of *Neoseps reynoldsi* have been taken in northern Marion County, Florida. The locality, near Lake Delancy represents a considerable northerly extension of the lizard's known range. The collection area is 37 miles north of the nearest previous locality, and increases the total north-south distribution to about 155 miles. The skinks were found in association with the red-tailed skink, *Eumeces egregius* (Baird), in sandhill habitat, with yellow Lakewood sand.

This new locality may well represent the farthest north *Neoseps* should be expected. It was probably at or very near the shoreline of the "Suwannee Straits" which separated the Florida islands from the mainland in interglacial times (Neill, 1957). Telford (1959) suggested that *Neoseps* may have evolved on the island outlined by the Wicomico Terrace in the early Pleistocene. For his shorelines and dates, Telford used Cooke (1945) who depicted the Wicomico Terrace as a large island extending from Alachua County south to Highlands County. MacNeill (1950) sees the Wicomico Terrace as several islands, including a large one from Lake County south to Highlands (Lake Wales Ridge) and a small one at the Lake Delancy region in northern Marion County. The known locality records of *Neoseps* fall within the large island and the Lake Delancy area here reported.

Since Telford's paper, Alt and Brooks (1964) give evidence that the age of the Wicomico may be much greater than Pleistocene; probably Pliocene. If this were the case, it would have allowed a longer period of isolation for *Neoseps*: when the waters receded at the end of the Sangamon interglacial period, the lizard was still isolated and prevented from dispersal because of the lack of suitable habitat. Even in more recent times there appears to have been no dispersal for this reason.

The presence of *Neoseps* in the Lake Delancy area as well as the Lake Wales Ridge, the area in between having been submerged during the Sangamon, indicates the need for a slight revision of Telford's hypothesis. *Neoseps* must have been well on its evolutionary path of development *before* the rise of sea level which separated the Lake Wales Ridge from the Lake Delancy area. It is thus indicated that *Neoseps* developed before the Sangamon interglacial period, and was subsequently isolated and restricted to at least two of the land masses that remained above water during that final rise in sea level. The fact that the specimens collected at the Lake Delancy area are virtually identical with Lake Wales Ridge material indicates that the specialized adaptations of *Neoseps* were present before the separation of these two populations.

Examination of MacNeill's (1950) map of the Wicomico Terrace, and comparison with soil and vegetation maps shows that several other small areas may still support *Neoseps* populations. The outlook for this Florida endemic thus seems a little more optimistic than that feared by Telford (1969).

I have collected what is apparently another Lake Wales Ridge endemic at this same Lake Delancy area. Skinks which fit Mount's (1965) description of *Eumeces egregius lividus* make up about 25 per cent of this species collected around Lake Delancy. Unfortunately I have been unable to get a live specimen to Dr. Mount for his opinion, but Dr. Telford, who saw much of Mount's original material, agrees that the specimens in question fall into the range of color variation of the blue-tailed subspecies.

Eumeces egregius is much less restricted in habitat requirements than is *Neoseps*, and doubtless mixing of *onocrepis* with *lividus* in the small Lake Delancy area is occurring. But the fact that *lividus*-like lizards are present indicates a similar evolutionary background for the two skinks. Everything that has been postulated for the history of *Neoseps* may well apply to *Eumeces egregius lividus*.

Shortly after death, one of the *Neoseps* was examined under the dissecting microscope. Packs of sand were evident around the nostrils. Pough (1969) notes this situation in the sand-adapted lizard *Uma notata*, and suggests its significance in preventing inhalation of single grains of sand.

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The Effects of Different Ratios of Force on Aggression

James Tindell and Jack E. Vincent

This paper deals with a two-person game which was developed and first employed by Shure, Meeker, and Hansford (1965) to investigate the effect of a "pure pacifist" strategy on subjects' cooperative and aggressive behavior. Their results stimulated Vincent and Tindell (1969) to utilize a modified version of the game to investigate the effects of a "warning pacifist" strategy and a "retaliating pacifist" strategy on subjects' behavior. (The terms "pure," "warning," and "retaliating" pacifist are explained below).

The Shure, Meeker, and Hansford experiment may be summarized as follows: 143 subjects were asked to transmit messages in a communications system with the following conditions and restraints: (1) all messages had to be entered into a communication channel with a total storage capacity of six message units, (2) each subject could only enter one letter of the message at a time in the communications channel, (3) only a complete message, of five units, could be transmitted; (4) only one subject could transmit at a time, because each subject needed five of the six units of capacity within the common channel to transmit; (5) deadlock occurred and neither subject could transmit if both subjects attempted to transmit at the same time; for example, if both entered three letters apiece into the common channel. (In such a situation, it was necessary for one of the subjects to withdraw two letters before the other could transmit).

The basic objective of the game was to send as many messages as possible during a fixed work period consisting of 15 turns. A player could enter or withdraw a letter or take no action during each turn. Successful transmissions were rewarded by monetary payment.

Each player was told that he was playing some other person, but actually he was playing against a pacifist strategy programmed into a computer. The strategy consisted of (1) allowing the subject to transmit first and thus giving him the jolt-back ability (explained below), (2) entering the common channel during the second work period and thus, in effect, making a claim to a division of the earnings; and (3) never shocking the subject. Thus, as de-

scribed by Shure, Meeker, and Hansford (1965, p. 113), "with each incoming S our simulated pacifist makes an initial demonstration of good faith by letting the other man go first; he always makes the claim that alternation is fair; if he meets an aggressor, he invariably stands in the way to force the use of violence until his claim is responded to; and finally, he himself never resorts to retaliation with electric shock." To further enhance the possibility of a dominance-submission pattern emerging, each subject was placed on a 3-man team, with the other two members acting in collusion with the investigator to urge the subject to be dominant.

The major finding of the experiment, summarized by Shure, Meeker, and Hansford (1965, p. 116), was: "Reassured by their knowledge of the pacifist that they could dominate with impunity, they did not soften their demands but planned for continued exploitation. The pacifist's tactics apparently invite exploitation and aggression even among those who do not begin with such intentions."

Vincent-Tindell (1969, p. 496) questioned the results of the Shure, Hansford, and Meeker experiment and argued: "Here is a simulated pacifist of such complete dedication to pacifism that his only comparison could be with Christ, a pacifist who gave the other fellow the first turn, made his good deeds known by justly attempting to enter a communications channel, and then allowed himself to be forced out of the channel and shocked with retaliation, and, even more remarkable, threw away all of his weapons at mid-game (for one-half of the Ss). Is it possible that such a Christ-like figure bordered on the unbelievable to the California sophomores?"

In view of this, they decided to distinguish between a "pure pacifist" (the SMH strategy), a "warning pacifist," and a "retaliating pacifist" as possible cooperative strategies. The principal difference was in amending the original strategy by adding "threat" and "retaliation." The warning pacifist indicates during game play, with a warning light, that he is about to shock in all those situations where it would be justifiable for him to shock. That is, in contrast to the SMH pacifist, he threatens his opponent, even though he never fulfills this threat. In all other characteristics of play, however, he remains the same, that is, he lets the other fellow go first, he makes his claim to his fair share, and he is consistent to his dedication to cooperation on all things, e.g., by initiating de-escalation during the game (even if his opponent hasn't). The retaliating pacifist

simply carries things a step further. He not only warns, in the appropriate circumstances, but he also shocks. He never shocks aggressively, however, but only in retaliation for an unjustifiable shock by his opponent. Hence, he is a "perfect cooperator," as are the warning pacifist and the pure pacifist, but he retaliates when he has been unjustifiably stepped on.

To economize experimentally, the results of the SMH experiment were accepted and the primary problem became one of subjecting the subjects to two experimental conditions, i.e., the retaliating pacifist and warning pacifist strategies. In addition, certain additional variables such as grade point average, sex, etc., were concurrently investigated. To accomplish these objectives, certain modifications were made in game design.

These were to add to the capabilities of the SMH game, additional switches allowing (1) warning of intention to shock, (2) wish to de-escalate, and (3) de-escalation (any number of units of shocking power could be given up). Unlike the California experiment, however, no computers were employed in the game play; the subjects' responses were handled by the principal investigators using a central control panel.

Tindell and Vincent (1969, p. 504) concluded, "When college Ss were asked to play a bargaining game based on the SMH model, a 'warning condition' produced results, in respect to shocks used, similar to the SMH game. Most Ss were highly belligerent and willingly shocked a pacifistic opponent dedicated to pacificism (non-shocking), de-escalation and cooperation. A 'shocking condition' produced effects statistically different from the warning condition in the direction of 'belligerency,' that is, by apparently stimulating the Ss to use more shocks, make fewer cooperative moves and win more games and game points. This finding led to a criticism of the SMH conclusions which were based on the assumption that the lack of retaliation in the SMH game had 'invited' aggression. This study suggested that the opposite might be true, that is, that retaliation may actually stimulate aggression in this game."

Purpose of This Experiment

As discussed above, when *simulated* subjects returned the aggressive acts of *experimental* subjects, the result was more aggressive behavior on the part of experimental subjects exposed to this

treatment condition. This raised the question of whether there were other factors which influence the aggressiveness of experimental subjects. It also raised the important question of whether other factors could be found which influenced the degree of aggressiveness of experimental subjects when *no* simulated subjects were used in the experiment. From these questions came the purpose of this experiment, which is to investigate whether the number of shocks experimental subjects are allocated (relative to their non-simulated opponents) affects their game behavior. The experimental conditions were constructed by dividing a total of 40 shocks in different proportions among three groups of 18 randomly assigned subjects. The experimental conditions were (1) a balanced distribution of shocks (in which all subjects were allocated 20 shocks each), (2) a moderately imbalanced distribution of shocks (in which certain subjects were given 25 shocks while their partners received 15 shocks, (3) a preponderantly imbalanced distribution of shocks (in which certain subjects were given 30 shocks while their partners received 10 shocks). All subjects were informed of the number of shocks they and their opponent possessed.

The experimental conditions were suggested by certain propositions in international relations which deal with the maintenance of peace among nations. Many such propositions imply or declare that the distribution of "force" (or "power") among nations is a factor influencing the level of cooperation and aggression in the international realm. For example, Morgenthau (1961, p. 167) has stated that a "balance of power" situation is imperative for world peace. With respect to this he says:

> The balance of power and policies aiming at its preservation are not only inevitable, but are an essential stabilizing factor in a society of states.

However, other political observers have stated exactly the opposite opinion. Organski (1958, p. 27) believes that a "preponderance of power" in the hands of an international actor or allied actors is the distribution of force most likely to foster peace and stability. He says:

> A balance of power does not bring peace; on the contrary, the greatest wars of modern history have occurred at times when one of the challengers most nearly balanced the power of the preponderant nations or . . . thought that its power was as . . . great as that of its

> rivals. . . . A preponderance of power on one side, on the other hand, increases the chances of peace, for the greatly stronger side need not fight at all to get what it wants, while the weaker side would be plainly foolish to attempt to battle for what it wants.

Unfortunately, the veracity of either of the above positions resists direct testing in the international arena. For that reason, this experiment was constructed to investigate the effect of "*distributions of force*" on subject behavior in the '*world of simulation.*"

With respect to the value of simulation and gaming research the authors agree with Martin Shubik (1968, p. 96) who has pointed out the difficulty of extrapolating from the findings of game and simulation research to the "real world," but adds:

> I believe, however, that a considerable contribution to the body of knowledge needed for the understanding of bargaining and negotiation processes can be made by controlled gaming experiments and small simulations.

To summarize, then, an experiment using a two-person game will be used to collect data on the behavior of subjects for the game-play variables listed below. The major experimental variable being investigated is the effect on the subject behavior of allocating different ratios of shock to pairs of competing subjects. The two extremes of the shock ratios (a balanced shock ratio condition and a preponderantly imbalanced shock ratio condition) were suggested by the difference in opinion between Morgenthau and Organski regarding which relative distribution of force is most likely to further peace and cooperation.

GAME DETAILS

The game is a contest where subjects attempt, on as few moves as possible, to light five lights on a panel before them. Three panels were used in the experiment, one panel for each subject and a control panel for the experimenter. Each of the five lights on a subject's panel can be turned on or off, individually, by a switch located beneath each of them. The subjects are instructed to attempt to turn on one light, going from light number 1 to light number 5, each time a "game light" on their panels comes on. The "game light" is operated by the experimenters. Each subject is told that the other player is also lighting his lights, and that when both

players have lighted their first three lights all the available spaces in the experimenter's six-space control panel will be filled. This creates a situation where neither player can advance (i.e., light the next light) unless one player retreats by switching off one of his lights, allowing the other player to advance into the vacated space.

To win a game a subject must light all five of his light spaces. This means that he is in five of the available six spaces on the experimenter's control panel (i.e., the other player is only in light space number 1).

In addition to the five switches mentioned above, each player's panel contains a shock switch and a warning switch. These switches can be used at any time during a game. However, a player must send a warning to the other player and then wait one trial before using the shock switch. The warning and the one trial wait before using the shock switch are to allow the other player time to evacuate a contested light space.

The player who wins a game will see a "jolt-back power" light come on his panel. This light indicates that by simultaneously using both his shock switch and a contested light space switch he can force the other player out of the contested space. If he loses or draws a game, this "jolt-back power" reverts to the other player. But, a player who does not have "jolt-back power" is not defenseless; he can shock back each time he is shocked. However, he cannot force his opponent out of contested light spaces without the "jolt-back power."

A draw is declared when the subjects play five consecutive trials at one light, neither backing up or going forward. As indicated above, *the player having "jolt-back power" loses it if he allows a game to end in a draw, or allow the other player to win a game.*

The subjects' panels also have a de-escalation intent and a de-escalation switch. These switches can be used at any time and as often as desired during the game. The purpose of these switches is to allow a player to signal either an intention to de-escalate or to actually de-escalate. Each player has a predetermined total number of shocks and by pushing his de-escalation switch a player has informed the experimenter and the other player that he desires one shock to be subtracted out of his shock bank.

All subjects are instructed to win as many "game points" as possible. Each subject starts the game play with 100 points. When a

subject wins a game (by lighting all five of his lights) he receives 10 points. However, there is a charge of one point to both players each time the game light comes on. Therefore, the maximum number of points a player can win is affected by the number of light spaces which are contested. In a game where there are no contested light spaces the game light will have come on five times and the winner's net profit is five points. The loser in a non-contested game is awarded two points apiece for the two spaces he *voluntarily* moves out of. Hence, he receives a net loss of only one point. In a contested game the loser must have been involuntarily forced back by the other player's "jolt-back power" and does not receive the two point bonus per surrendered light space. In the case of games termed a draw, both players are charged as many points as there have been game lights up to the time the draw is declared.

Game Play Variables

Each subject's score is recorded on the nine game-play variables listed below. The assumption is made that each variable can be considered an index measuring the propensity of a subject to be cooperative; or aggressive; or de-escalative, etc.

For some of the variables an experimental effect is predicted on the basis of *our* interpretation and extension of what Morgenthau or Organski have indicated the effect of different force ratios might be. For example, following Morgenthau's line of argument we might expect that less aggressive behavior would occur in the balanced, equal shock ratio condition, while following Organski's argument we might expect less aggressive behavior in the preponderantly imbalanced shock ratio condition. In most cases, *our* interpretation of Morgenthau would lead to a prediction exactly opposite of one based on our interpretation of Organski (and vice versa). Therefore, to reduce redundancy, we have generally ventured a prediction based on either one position or the other, rather than both. These predictions are for the sake of contrast only and are not viewed as justifying one-tailed tests of hypotheses.

The number of shocks used. A count is made of the number of times each subject uses shock. The higher this score the more aggressive a subject is viewed. In terms of Morgenthau's arguments, we expect fewer shocks to be used by the subjects in the balanced condition than those in the preponderantly imbalanced condition.

The proportion of the shock supply used. The number of shocks a subject uses is divided by the number of shocks he initially received. This variable is considered to be an index of a subject's aggressiveness, calculated, however, in terms of his original shock capabilities. In line with Morgenthau's position, we would predict the subjects in the balanced condition to use a smaller proportion of their shock supply than the subjects in the imbalanced conditions.

The number of cooperative moves. Each *voluntary* surrender of a light space by a subject is scored as a cooperative move. Following Morgenthau's line of thought we would predict the subjects in the balanced condition to make more cooperative moves than the subjects in the imbalanced conditions.

The number of games won. The number of games a subject wins is scored for each subject. This variable is considered an index indicating how strongly a subject dominates the other player. Following Organski's line of thought we would expect the powerful subjects in the imbalanced condition to win more games than the other groups of subjects.

The number of points won. Each subject's point score was tabulated and recorded. This variable indicates the degree of success a subject had in the experiment. (Since subjects can "win" games while actually losing points, if there is a large number of stalemates, threat messages, draws, etc., this variable is considered a more accurate index of "success" than the number of games won variable would be). If Morgenthau is correct about balanced situations maximizing cooperation, then, we would expect the subjects in the balanced condition to win more points than the subjects in the imbalanced conditions. (This prediction is due to the structure of the game. Even a "perfect dominator," who wins every game, would (if resisted) have to waste so many game points, in warning his opponent and then jolting him out of contested light cells, that the net point winnings of the dominator would be less than that of either player in a perfectly cooperative dyad).

The number of games drawn. The number of games drawn during the experiment was scored for each subject. This score is an index of non-cooperation, of a peaceful sort. That is, peaceful in the sense that in any game one of the subjects has the "jolt-back

power" and by virtue of this could win the game. Following Organski's line of thought, we would not expect the powerful subjects in the imbalanced condition to allow many draws or the "weak" subjects to view drawing as a meaningful strategy. Thus, if we accept Organski's position, we would expect the balanced situation to engender more drawn games.

The number of intended de-escalations. The number of intended de-escalations for each subject was recorded. This score was considered an index reflecting the desire of a subject to instigate de-escalation cycles when he follows through with actual de-escalations. It can be considered an index of perfidiousness when the subject does not follow through with de-escalations in that he is attempting to get his opponent to de-escalate when he has no intention of doing so himself. No prediction in terms of Morgenthau or Organski seemed warranted for this variable.

The number of actual de-escalations. The number of times a subject voluntarily reduces the number of shocks he has was recorded. This variable was interpreted as measuring the desire of subjects to reduce the extent of actual physical threat present in the experimental situation. The variable was incorporated in the experiment to find out whether graduated de-escalation cycles would evolve among the uninstructed dyads (Osgood, 1962). No predictions were made.

The number of false warnings. This was calculated by subtracting the number of warnings followed by a shock from the total number of warnings sent. This score was considered an index of a subject's tendency to threaten or bully the other player. Organski states that weaker parties will acquiesce to a more powerful opponent. In that case we would expect to see more false warnings (i.e., warnings which do not need to be fulfilled in order to achieve the sender's desires) to be sent by the powerful subjects in the imbalanced treatment conditions.

SUBJECT RECRUITMENT AND ORIENTATION

Subjects for the experiment were recruited out of upper-division Social Science classes at Florida Atlantic University. Although electrical shock was employed in the game, no mention of this was made in the initial recruitment effort. In all, 54 subjects participated in the experiment. Because shock was used, a damage re-

lease was necessary to protect the university and the experimenters from any claims of injury. A release statement was drawn up and signed by all subjects prior to participation. In order to lessen fear of shock, it was emphasized that all shocks were transmitted through a control panel and that no shock would be administered unless the sender warned the receiver and then waited for at least one game light to allow the intended receiver of the shock sufficient time to cooperate. It was also made clear that subjects could quit at any point during the game.

Although some subjects, in particular females, expressed fear, only one subject, male, refused to participate because of shock and none of the remaining subjects quit before their series of 15 games was completed. In fact, some subjects who initially manifested extreme fear turned out to be surprisingly willing to both give and receive electrical shocks once embroiled in the game.

Before being taken to the experimental room each subject was given an explicit set of rules concerning game play. Ten minutes were set aside before the actual start of the game to allow the experimenter to cover important points and to allow trial games on the experimental equipment. Caution was exercised at all times by the experimenters to keep bias out of their instructions or in responses to questions.

The adjacent rooms in which the experiment was conducted were specifically designed for social science research and contained one-way mirrors allowing observation of the subjects by the experimenters. Each subject was seated in a separate room (approximately 10 ft by 15 ft in size) facing a game play panel.

Prior to actual game play each subject identified "a quite irritating level" of electrical shock. This was accomplished by telling the subject that electrical shock would initially be transmitted to his wrist at a very low voltage; the current was then raised in small steps until the subject indicated it was quite irritating. The voltage at this level was noted by the experimenter for each subject and was used as the level of shock the subject received throughout game play. The two electrical diodes which transmitted the shock were coated with a pure glycerin compound. The diodes were approximately the size of a dime and were attached to the opposite sides of an elastic band which was snugly fastened around the subject's wrists.

ANALYSIS

The experimental design and analysis was adopted from Winer (1962). This analytic model employs analysis of variance to test any observed differences between the mean scores of the experimental groups on a game play variable for statistical significance. The analysis approaches the subjects' game play for each variable from the three perspectives discussed below.

The mean number of responses made by the subjects in the balanced condition was compared with the *combined mean* number of responses made by the subjects in the two imbalanced ratio conditions. A significant difference between these means indicated that the subject game behavior differed (with respect to that game variable) between the subjects in the equal shock ratio condition and the subjects in the unequal shock ratio conditions.

The subjects participating in the imbalanced conditions were classified into four categories a) subjects in the moderately imbalanced condition who were allocated 25 shocks, b) subjects in the moderately imbalanced condition who had 15 shocks, c) subjects in the preponderantly imbalanced condition who had 30 shocks, and d) subjects in the preponderantly imbalanced condition who had 10 shocks. A mean score on each variable was calculated for each of these four groups. This mean was then compared with the mean response of the subjects in the balanced condition. A significant difference between the means of any of these comparisons indicated which (if any) of the four groups in the unequal shock ratio conditions were responding differently than the subjects in the equal shock ratio condition.

The final step in the analysis of the experimental data was a two-factor analysis of variance which considered only those subjects in the imbalanced treatment conditions. The mean number of responses of the "powerful" subjects (those having 25 or 30 shocks) was compared with the mean number of responses of the "weak" subjects (those having 10 or 15 shocks); also, the mean number of responses of the subjects in the moderately imbalanced condition was compared with the mean number of responses of the subjects in the preponderantly imbalanced condition. This part of the analysis was to provide information about which, if either, of the unequal treatment condition factors (the degree of the imbalance of the shock ratio, or the subject placement in the powerful or

weak condition within the imbalanced conditions) was significantly affecting subject behavior on a game variable.

Steps number one and three above used an "F" ratio to test differences between the treatment condition means for significance. This ratio was calculated by dividing the variance of a variable attributable to treatment effects by the variance attributable to the random variation of subjects' responses on that variable. The larger this ratio (adjusting for the number of observations, treatment conditions, etc.) the less likely it is the observed differences between the means are due to chance. T-tests were used in step two to determine whether any of the differences between the means of the four subgroups in the imbalanced conditions and the mean of the balanced conditions were significant.

This research was of an exploratory nature so the level of significance chosen for reporting was $p > .10$. The numerical value and level of significance of the F-ratios and t-tests for the game play variables which were significantly affected by the experimental treatment conditions are listed in the tables, which reflect the three analytic perspectives discussed above.

Tables 1, 2, and 3 list a total of 13 significant experimental effects on the game play variables. The significant results listed for each variable will be considered in turn. Bar charts have been constructed to depict the subject behavior on the variables listed.

Figure 1A shows that the subjects in the imbalanced conditions used more than twice as many shocks as the subjects in the balanced condition, 8.55 compared with 4.0, or, in terms of the proportion of the shock supply used, .49 compared with .20. When the proportion of the shock supply used is graphed, it looks much the same as the graph of the numbers of shocks used in Fig. 1A, (i.e.,

TABLE 1

Game play variables for which the behavior of the subjects in the balanced condition was significantly different from the behavior of the subjects in the imbalanced conditions.

Variable	F-Ratio	Degrees of Freedom	Probability
The number of shocks used	5.42	1/24	$p < .05$
The proportion of shocks used	6.56	1/24	$p < .05$

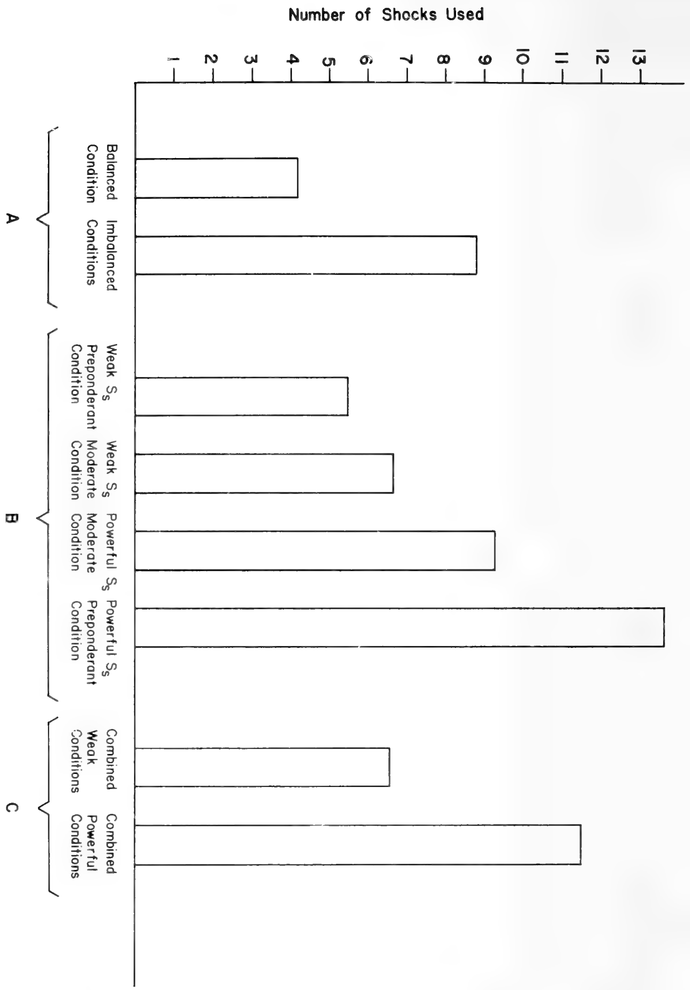

Fig. 1. Number of shocks used, displayed for the following analytical perspectives: A, comparison of balanced versus imbalanced conditions; B, four subgroups in imbalanced condition; C, comparison of "weak" subjects versus "powerful" subjects in imbalanced conditions.

TABLE 2

Game play variable for which a significant difference was found between one (or more) of the four groups of subjects in the imbalanced conditions compared to the subjects in the balanced condition.

Variables and Treatment Condition	t-test	Degrees of Freedom	Probability
1) *The number of shocks used*			
A. Powerful subjects in the moderately imbalanced condition.	2.35	24	$p < .05$
B. Powerful subjects in the preponderantly imbalanced condition.	4.33	24	$p < .005$
2) *The proportion of shocks used*			
A. Weak subjects in the preponderantly imbalanced condition.	3.15	24	$p < .01$
B. Powerful subjects in the preponderantly imbalanced condition.	2.32	24	$p < .05$
3) *The number of intended de-escalations*			
A. Weak subjects in the moderately imbalanced condition.	2.77	24	$p < .025$
4) *The number of false warnings*			
A. Powerful subjects in the moderately imbalanced condition.	3.37	24	$p < .01$

more than twice as high for the subjects in the imbalanced conditions). Therefore, it was decided not to include a repetitive bar chart for the "proportion of the shock supply used" for this analytic comparison.

As shown, the subjects in the imbalanced conditions used more shocks than the subjects in the balanced condition. This, of course, may be an indication that the "balance of power" situation favored by Morgenthau is conducive to less aggression than "imbalances of power," in particular, the preponderantly unequal imbalance of power. The average "number of shocks used" by the powerful subjects in the preponderantly imbalanced condition was 9.22 more per subject than was used by the subjects in the equal shock ratio condition, Fig. 1B.

The moderately imbalanced condition, however, also was the scene of a good deal of aggressive activity on the part of the subjects having more shocks than their opponents. There the "number of shocks used" by the group of subjects having 25 shocks was, on

TABLE 3

Variables for which there was a significant difference in the subject behavior between either the combined weak and the combined powerful subjects or between the moderately imbalanced and the preponderantly imbalanced treatment condition.

Variable	F-Ratio	Degrees of Freedom	Probability
1) *The number of shocks used*			
A. Combined weak versus combined powerful subjects	9.12	1/24	$p<.01$
2) *The number of cooperative moves*			
A. Combined weak versus combined powerful subjects	5.81	1/24	$p<.05$
3) *The number of games won*			
A. Combined weak versus combined powerful subjects	8.68	1/24	$p<.01$
4) *The number of false warnings*			
A. Combined weak versus combined powerful subjects	5.13	1/24	$p<.05$
B. Moderately imbalanced versus preponderantly imbalanced treatment conditions	6.85	1/24	$p<.05$

the average, five more per subject than was used by the subjects in the equal shock ratio condition, Fig. 1B.

Given the very large number of shocks used by the subjects in the imbalanced conditions, it comes as no surprise that, as shown in Fig. 1C, the "number of shocks used" by the powerful subjects in the unequal shock ratio conditions was significantly larger than the number of shocks their weaker opponents used, 11.11 compared to 6.39.

In terms of the proportion of the shock supply used, both the powerful and the weak group of subjects in the preponderantly imbalanced shock ratio condition used a significantly larger portion of their shock supply than the subjects in the balanced condition. Figure 2 illustrates that the weak subjects used 33.3 per cent more of their shock supply than the subjects in the equal shock ratio condition, while the powerful subjects used 24.2 per cent more of their shock supply than the subjects in the equal shock ratio condition used.

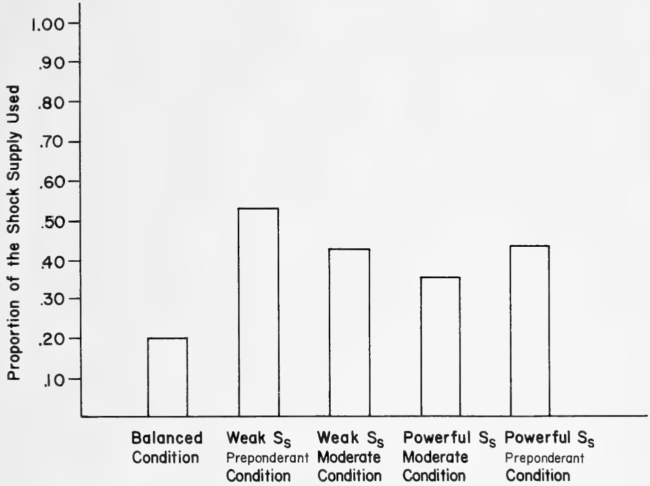

Fig. 2. Mean proportion of shock supply used by subjects in balanced condition compared with the four groups of subjects in imbalanced conditions.

The difference between the number of shocks used by the powerful and the weak subjects in the unequal shock ratio conditions was accompanied by a significant difference in the number of cooperative moves made by these groups. Figure 3 shows that the powerful subjects made only .94 cooperative moves per subject while their opponents made 6.89 cooperative moves per subject. This tendency of the weaker subjects to be more cooperative than their opponents agrees with what we felt Organski might have expected from an imbalanced distribution of power. However, it should be noted that the number of cooperative moves the weaker subjects made was not significantly larger than the number made by the subjects in the balanced situation. Thus, it cannot be said that the imbalanced situation increased the level of cooperation of the weaker subjects above the level of cooperation expected in a balanced distribution of force. It appears more likely that the effect of the imbalance was in the direction of reducing the number of cooperative moves made by the powerful subjects.

The difference between the degree of cooperativeness of the powerful and weak subjects, of course, also affected the number of

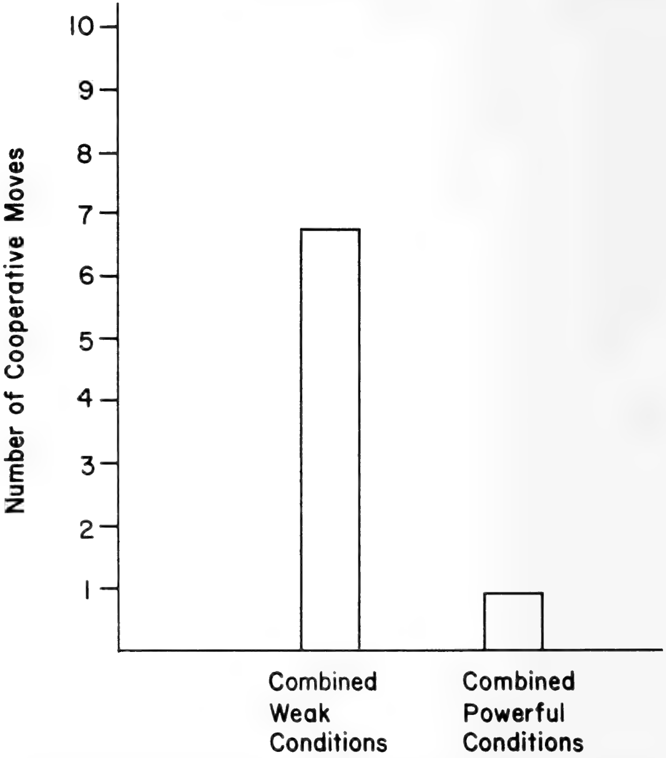

Fig. 3. Mean number of cooperative moves, shown for combined group of "weak" subjects in imbalanced condition and combined group of "powerful" subjects in imbalanced condition.

games these groups won. Figure 4 illustrates the significant difference between the "number of games won" by the subjects having a larger number of shocks than their weaker opponents. The two groups of powerful subjects in the imbalanced conditions won an average of 5.5 games per person, while their opponents won an average of .89 games per person. This result also conforms with the prediction based on our interpretation of Organski's position. Again,

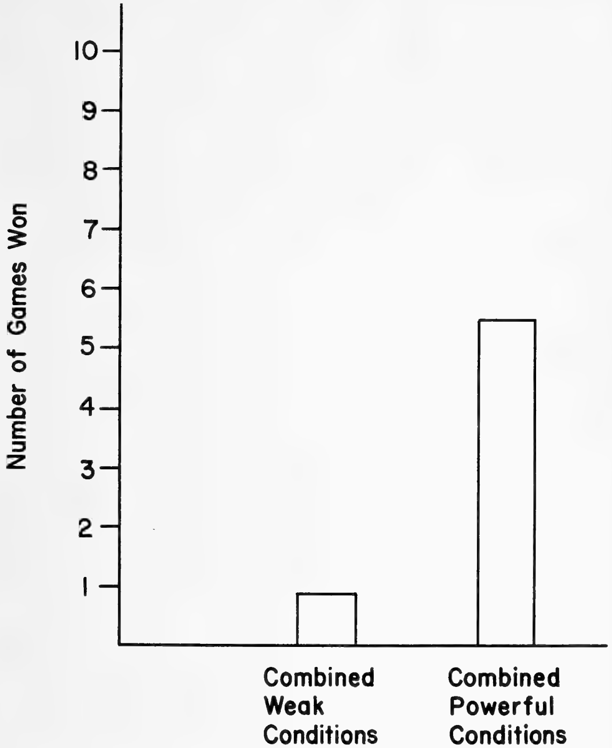

Fig. 4. Mean number of games won shown for "weak" group of subjects in imbalanced condition and "powerful" group of subjects in imbalanced condition.

however, it is important to note that there was not a significant difference between the number of games won by the subjects in the balanced condition and the powerful subjects in the imbalanced conditions. The imbalanced conditions appear to have mainly resulted in an exaggerated difference between the number of games won by the weak and the powerful groups, but with neither group differing significantly from the subjects in the balanced condition.

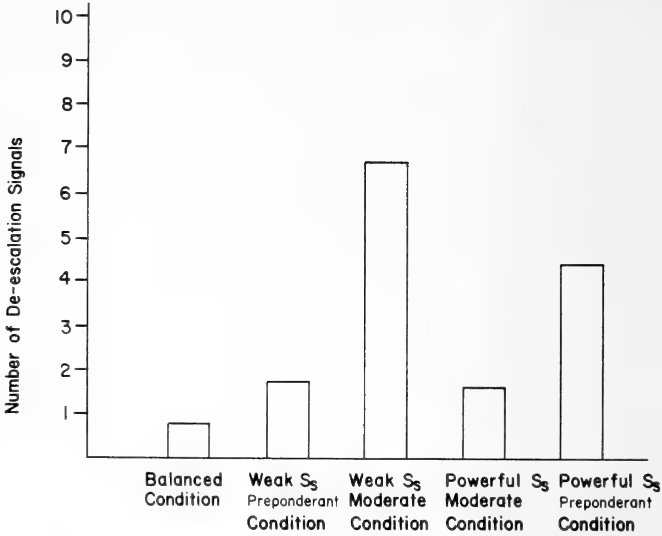

Fig. 5. Mean number of intend to de-escalate signals, shown for subjects in balanced condition and the four subgroups in imbalanced condition.

No prognostications were made for the two variables dealing with de-escalation, but a significant difference did emerge for the number of "intend to de-escalate" signals variable. Figure 5 illustrates that the group of subjects having 15 shocks made an average of 6.07 more "intend to de-escalate" signals than the subjects in the equal shock ratio condition. Since most of these signals were not followed by an actual de-escalation, it becomes a moot point as to whether they should be interpreted as attempts at establishing de-escalation cycles, or as attempts to trick the other, more powerful, player into discarding some of his advantage in shocks.

The prediction for the "number of false warnings" variable, based on our interpretation of Organski, was correct. The powerful group of subjects in the unequal shock ratio conditions made more false warnings than did the weaker group of subjects. Figure 6A shows that the more powerful subjects made an average of 6.77 false warnings per subject compared with the weaker group's av-

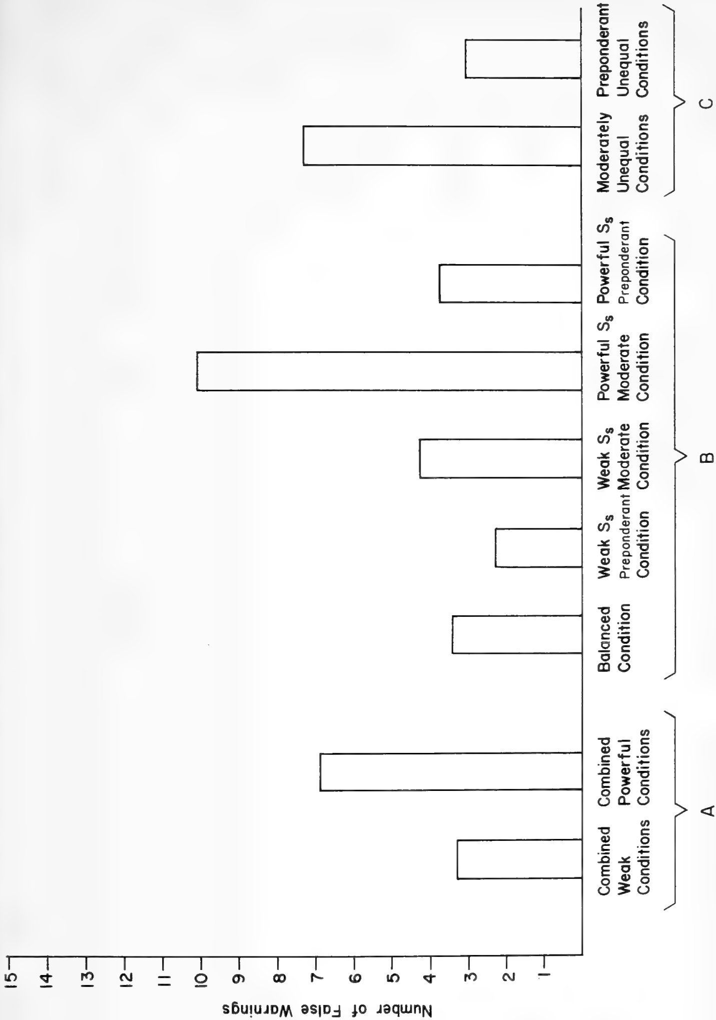

Fig. 6. Mean number of false warnings, shown for following analytic perspectives: A, comparison of "weak" subjects versus "powerful" subjects in imbalanced condition; B, comparisons of four imbalanced subgroups with the balanced conditions; C, comparison between moderately unequal treatment condition and preponderantly unequal treatment condition.

erage of 3.22 false warnings per subject. This result, in part, is attributable to the extremely large number of false warnings sent by the group of subjects having 25 shocks. This was the only one of the four groups of subjects in the imbalanced conditions that sent a significantly different number of false warnings than the subjects in the balanced condition. Figure 6B shows that this group of subjects made 6.48 more "false warnings" per subject than the subjects in the equal shock ratio condition.

The large number of false warnings sent by the powerful subjects in the moderately unequal shock ratio condition also played a role in the finding that the moderately unequal shock ratio condition differed significantly from the preponderantly unequal shock ratio conditions with respect to the "false warnings" variable. Figure 6C illustrates this difference; the subjects in the moderately unequal shock ratio condition made 7.05 average false warnings per subject while the subjects in the preponderantly unequal shock ratio condition made 2.94 false warnings per subject.

Significant differences were not found between any of the experimental groups for: "the number of games drawn," "the number of points won," and "the number of actual de-escalations."

Discussion

It was found that the number of aggressive acts made by subjects is related to the shock ratio condition in which they participated. Subjects in a balanced condition used significantly less shocks than subjects in an imbalanced condition, and they used a significantly smaller proportion of their total shock supply than the subjects in the imbalanced condition. These findings, of course, do not tend to support propositions such as Organski's (1958) that a distribution of force where one actor is considerably more powerful than his opponent tends to promote peace. Rather, the data tend to support Morgenthau (1961) and other proponents of a balanced distribution of force being less likely to instigate aggressive behavior.

However, some of the predictions based on our interpretation of Organski were correct, although other expectations, such as the "acquiescence of weaker parties," were not met. For example, the weak subjects in the imbalanced condition did make significantly

more cooperative moves than their stronger opponents, but they did *not* make significantly more cooperative moves than the subjects in the balanced condition. The experimental evidence indicates that the significant difference between the number of cooperative moves made by the weak and the powerful subjects in the imbalanced conditions was primarily due to the very low number of cooperative moves made by the powerful subjects, rather than a large number of cooperative moves made by the weak subjects. Additionally, the weak subjects did not, when compared to the subjects in the equal shock ratio condition, use less shocks than would have been expected if they had been given 20 shocks rather than the 15 or 10 shocks they received. In fact, both groups of weak subjects used a larger number of shocks than the subjects in the balanced condition. When the number of shocks used was translated into the proportion of the total shock supply used, it was found that the weakest group of subjects (having only 10 shocks) used a larger proportion of their shock supply than any other experimental group, and this proportion was significantly higher than the proportion of the shock supply used by the subjects in the equal shock ratio condition. We feel the above evidence indicates that relying on the acquiescence of a weaker party in a conflict is at best a dubious strategy.

One partial explanation of the difference between the number of shocks used by the subjects in balanced condition and the number of shocks used by the subjects in the imbalanced condition, is due to the large number of subjects in the balanced condition who refrained from using their shock capabilities even one time. In a sense we are here talking about the "deterrence" of aggressive behavior. To analyze this difference, each subject was classified as in either the balanced condition or the imbalanced condition; a count was then made of the number of subjects in each category which *never* once shocked their opponent. It was found that proportionately *five times* as many subjects in the equal shock ratio condition never shocked their opponents (five of the 18 subjects in the balanced condition never shocked their opponent, compared with only two of the 36 subjects in the imbalanced conditions who never shocked their opponent). Using Fisher's exact probability (Siegel, 1956, p. 96-104) the likelihood of a "chance" split this extreme or more was computed to be, $p < .039$.

In general, discussions of "deterrence" usually differ from dis-

cussions of "balance versus preponderance of power," by an emphasis on technological, strategic, and economic considerations. However, these discussions often entail arguments which support particular force ratios as optimal for deterrence purposes. Gareau (1962) compares some of the major positions regarding deterrence. The experimental data, when analyzed from this perspective, indicate that an equal distribution of force is more likely to deter aggressive acts than an unequal distribution of force.

It is interesting to note, by way of comparison to earlier experiments using this game, that 14 per cent of the subjects in the Shure, Meeker and Hansford (1965) study never used shock, 12 per cent of the subjects in the Vincent-Tindell (1969) experiment never used shock, and 13 per cent of the subjects in this experiment never used shock. This seems to reinforce the finding stressed in the Vincent-Tindell (1969) experiment that college students, for the most part, play this game in a highly belligerent fashion.

Given the more aggressive and uncooperative behavior on the part of the powerful subjects in the imbalanced conditions, one might assume this behavior to have been justified by their winning a large number of games. This is only partially true. For, although the subjects having 25 or 30 shocks did win significantly more games than their less powerful opponents, they did not win significantly more games than the subjects in the equal shock ratio condition. Instead, it appears, the powerful subjects succeeded mainly in decreasing the number of games the weak subjects would have been expected to win, rather than significantly increasing their own winnings. Furthermore, the "number of points won" variable, which we considered a more sensitive indicator of successful game play, did not differ significantly between any of the experimental conditions.

The large number of false warnings made by the subjects who were moderately more powerful than their opponents (i.e., the subjects having 25 shocks who faced an opponent having only 15 shocks) may indicate that moderately unequal ratios of force tend to elicit what might be called "bullying behavior." The term "bullying behavior" is meant to designate the behavior of those who desire a certain outcome and will resort to threats they apparently don't wish to fulfill, in an attempt to frighten and coerce a less

powerful protagonist into complying. However, the subjects who had only 15 shocks may have found an interesting way of responding to this large number of false warnings. They made more "intend to de-escalate" signals that were never followed through, than any other group of subjects. Perhaps there is some factor operative in relatively moderate disparities of force that engenders perfidiousness on the part of all involved.

A variable which should be mentioned, even though it was not significantly affected by any of the experimental treatment conditions, is the "number of actual de-escalations." This variable was incorporated into the experiment because of its conceivable importance and because it has been the focus of certain theoretical schemes in recent years. More specifically, Osgood (1962) has proposed a scheme for de-escalation which he calls "unilateral reciprocal initiative." Osgood's tension reduction model operates on the assumption that the current world situation is one of high tension and discomfort for the principal parties in conflict. Osgood hypothesizes that this dilemma is due to mistrust, suspicion, and fear, all of which he feels can be reduced or removed by carefully timed, gradual, and cautious de-escalative moves which are announced in advance, with an invitation, not a demand, for reciprocation.

Experiments to date have generated some, but by no means overwhelming, support for Osgood's graduated de-escalation scheme (Pilisuk and Skolnik, 1968). The Shure, Meeker, Hansford experiment (1965), which was not an attempt to test the Osgood *graduated* de-escalation scheme, found that even the complete voluntary surrender by a simulated subject of his weaponry was perceived as a ruse (in the main), and did not significantly reduce the number of aggressive acts made by the subjects exposed to this strategy.

To experiment with Osgood's gradual de-escalation scheme requires that at least one member of each dyad follow some sort of planned de-escalation strategy. Because of this, most of the experiments to date which have investigated Osgood's thesis have simulated opponents and use pre-planned de-escalation strategies. Rather than do that, we decided to simply include the alternative of de-escalating for the actual pairs of competing subjects in the ex-

periment. Unfortunate as it is, from a humanitarian perspective, it does not appear that naive subjects are likely to enter into de-escalation cycles, much less be affected by either the situation in which they find themselves or their opponents' manner of game play. Apparently, even highly cooperative pairs of subjects would rather maintain their shock resources than enter into de-escalation cycles.

One final comment. Five significant experimental effects were observed for the imbalanced conditions when the balanced condition was ignored. Four of these effects were attributable to the differences between the behavior of the powerful subjects and the weak subjects. One significant difference was found between the moderately unequal and the preponderantly unequal shock ratio conditions. *Thus, it may be that the existence of some difference between opponents in the amount of force they possess is a stronger influence on their behavior than is the actual numerical magnitude of the difference.*

SUMMARY

There are theories in international relations that relate the level of aggression in the international system to the distribution of power among nations. Unfortunately, most of these propositions are difficult to validate or refute in the world for which they were formulated. For this reason an experiment was performed which attempted, through simulation, to test propositions about "balance" *versus* "preponderance" of power.

The experimental paradigm employed was a modified version of the two person mixed-motive game developed at the Systems Development Corporation, Santa Monica, California. Fifty-four subjects participated in the experiment. Eighteen subjects were placed into each of three treatment conditions (1) "balance of power," where each subject was given 20 shocks; (2) "moderate-inequality of power," where certain subjects were given 25 shocks while their opponents were given 15 shocks and; (3) "preponderant-inequality of power," where certain subjects were given 30 shocks while their opponents were given 10 shocks. All subjects played a total of 15 games. A count was made of each subject's responses on eight game-play variables.

The results of this research indicate that an equal distribution of force tends to produce more cooperative and non-aggressive behavior than imbalanced distributions of force. In addition, a balanced situation, when compared to the imbalanced situations, was found to increase the likelihood of participants never once using their shock capabilities. Finally, de-escalation cycles did not evolve out of the unmanipulated game play of the pairs of subjects.

ACKNOWLEDGMENTS

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QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

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Thermal Analysis of Crandallite

Frank N. Blanchard

This study was undertaken as a result of encountering difficulty in interpreting thermograms produced by differential thermal analysis of complex mixtures of hydrous phosphate minerals (crandallite, wavellite, and variscite) and clay minerals contained in weathered phosphatic sediments from the Hawthorn Formation of northern peninsular Florida. A combination of differential thermal analysis, thermogravimetric analysis and x-ray diffraction analysis of pure crandallite from Fairfield, Utah, has led to characterization of the thermogram for crandallite and to interpretation of the thermal reactions, and this knowledge facilitates interpretation of thermograms of the complex mixtures of phosphate and clay minerals found in some of the Hawthorn sediments.

The crandallite used in this study is yellow microcrystalline material occurring in a banded crandallite-wardite nodule from Fairfield, Utah. The ideal formula for crandallite is $CaAl_3(PO_4)_2(OH)_5 \cdot H_2O$.

Methods

A sample of pure crandallite was obtained from the crandallite-wardite nodule by coarse crushing and hand picking to exclude particles of wardite and other associated minerals. The crandallite particles were then crushed and passed through a 200-mesh sieve.

Differential thermal analyses were made with a Fisher Model 260P Differential Thermalyzer. The output from a platinel differ-

ential thermocouple was amplified with a magnetic amplifier and the signal from the amplifier was used to drive the X-axis of a Houston Instruments Corp. Model HR-96 X-Y recorder. The Y-axis of the recorder was driven by the output from the furnace-temperature thermocouple, one junction of which was maintained at room temperature, and special graph paper was used to correct for nonlinearity of the thermocouple output. Preheated alumina was used as an inert reference material. Fractions of the crandallite sample weighing 100 mg were heated in silica crucibles at 5°, 10°, and 25° per minute from room temperature to about 1150 C, and at least three analyses were made with each heating rate. After some of the analyses the furnace was cooled to 500 C, and the heated crandallite was replaced with quartz; the temperature of the furnace was then raised, at the same heating rate used in the analyses, to above the temperature of the quartz inversion. This procedure gave a calibration check on the furnace temperature (quartz inversion at 573 C) and provided a reference for DTA peak magnitudes.

A discontinuous thermogravimetric analysis was carried out in a separate experiment in which four of the sample compartments in the DTA sample block were loaded with crucibles containing previously weighed quantities of crandallite. These crucibles were replaced, successively, at certain temperatures with crucibles containing alumina, and the heated crandallite was weighed and then used for x-ray analysis. In addition a 480 mg sample of crandallite was heated in a platinum crucible and maintained at certain temperatures for 30 minutes prior to weighing.

X-ray analyses of the heated crandallite samples shown in Fig. 3 were made with constant instrument settings and with the same quantity of sample. As a result significance can be given to relative peak heights. In an attempt to determine the compositional variety of apatite derived from heating crandallite (explained later) the heated crandallite was mixed with 15 per cent quartz and scanned six times on the diffractometer at 0.2° per minute from 44°-56° 2θ. Correction of the observed d-spacings for the apatite was accomplished by use of the 201, 112, and 202 reflections of quartz (as an internal standard). The 222, 312, 213, 410, 303, and 004 apatite reflections were used in refining the lattice constants using the least squares method and the computer program of Appleman and Evans (1967).

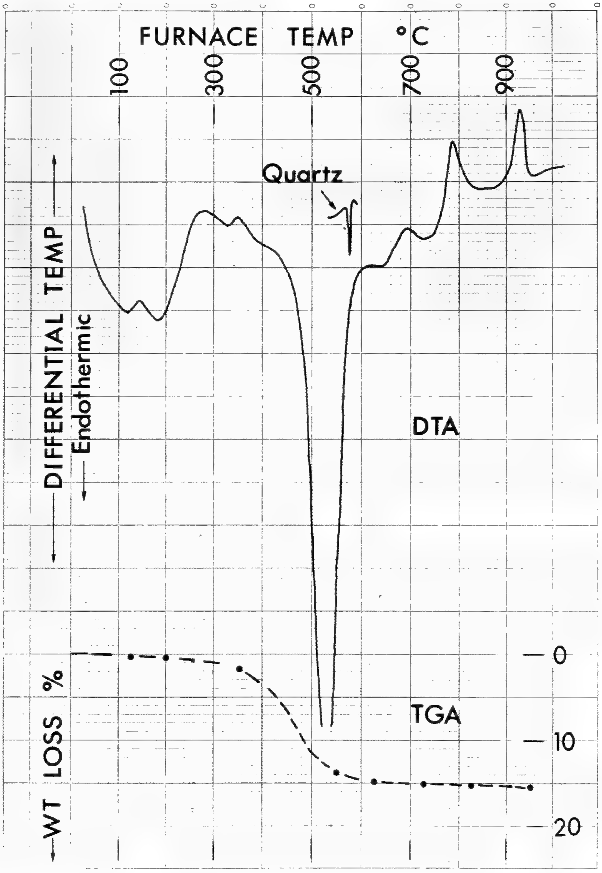

Fig. 1. Typical DTA curve and TGA curve for crandallite.

RESULTS AND DISCUSSION

Typical thermograms of crandallite are shown in Fig. 1. Weak

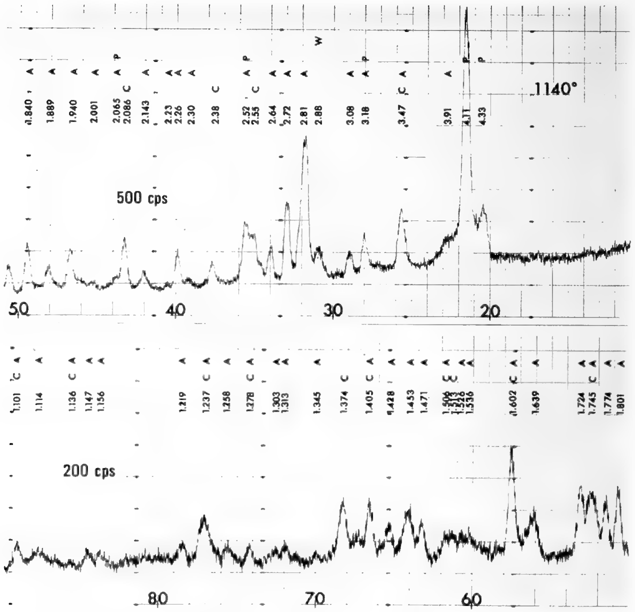

Fig. 2. X-Ray diffractometer pattern of crandallite after heating to 1140 C. The d-spacings (not corrected) are given for the various phases present (A=apatite, P=$AlPO_4$-cristobalite, C=corundum, W=whitlockite). The 2θ-scale is given for CuKα-radiation. Scanned at 0.4° 2θ per min.

endothermic reactions occur at 115° (loss of absorbed water), 180°, 330 C and a strong endothermic reaction appears at 530 C; exothermic reactions appear at 690°, 785°, 930°, and between 1070°-1150 C. At slower heating rates (5° and 10° per minute) the weaker thermal reactions vary in temperature and in some instances the temperature differential is so small that they cannot be detected with the methods used. Best sensitivity and greatest reproducibility of thermograms is obtained by heating at 25° per minute. Interpretation of the thermograms was aided or accomplished by means of thermogravimetric analysis and by x-ray diffraction analysis of samples after heating to various temperatures.

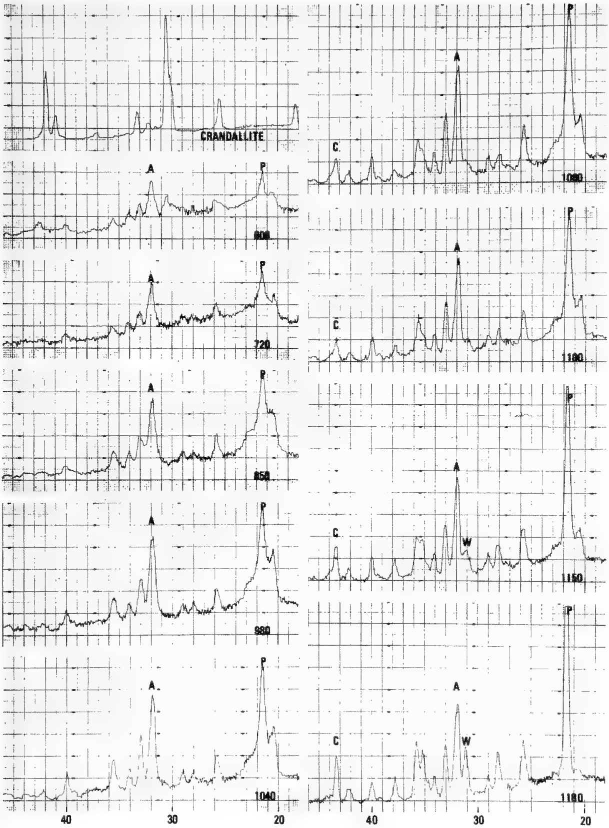

Fig. 3. X-Ray diffractometer patterns of crandallite after heating to various temperatures (600°, 720°, 850°, 980°, 1040°, 1080°, 1100°, 1150°, 1180° C, as indicated at lower right of each pattern). The strongest line for each phase is labeled: A=apatite, P=$AlPO_4$-cristobalite, C=corundum, W=whitlockite. The 2θ-scale is shown at the bottom (CuKα-radiation). Scanned at 2° 2θ per min.

Thermogravimetric analysis of crandallite (Fig. 1) indicates that the weak endothermic reactions at 180° and 330° are related to small losses of water (of crystallization?) and that the main endotherm at 530° is related to loss of most of the water of crystallization. Ideally, crandallite contains 15.23 per cent H_2O, but published analyses of crandallite show a slightly higher percentage and published analyses of crandallite from Fairfield, Utah show approximately 17.5 percent H_2O (Palache, et al., 1951). The amount of water lost after heating to 725 C (past the main dehydration endotherm and to the temperature where no crandallite lines appear in the x-ray pattern) is 14.96 per cent (assuming that water lost below 125 C is absorbed water), and even after heating to 950 C the total water loss is only 15.17 per cent. This indicates that some water is retained in the system after the main endothermic reaction and even above 950 C, and, as explained below, this water is probably present as OH in apatite which crystallizes from the crandallite. Continued slight loss of water at high temperatures (around and above 950°) probably occurs as apatite is converted to β-tricalcium phosphate (explained below).

In order to interpret the higher temperature thermal reactions x-ray diffraction was used to identify the phases present after heating crandallite to 130°, 270°, 350°, 600°, 720°, 850°, 980°, 1040°, 1070°, 1080°, 1100°, 1140°, 1150°, and 1180 C (Figs. 2 and 3). In most cases the material was slowly cooled in the furnace over a period of four hours, however, no detectable difference resulted from rapid cooling.

X-ray patterns for samples heated up to 350° (past the weak endothermic reactions) show no change from the original crandallite pattern. Crandallite heated to 600° shows a very weak x-ray reflection corresponding to the strongest reflection for crandallite and shows weak reflections indicating the presence of new phases (Fig. 3). These new phases are better developed in material heated to 980° and the sample heated to 980° was scanned from 2°-90° 2θ in order to identify the phases present. Interpretation of the resulting pattern indicates that all of the reflections can be accounted for by a mixture of apatite and $AlPO_4$-cristobalite. The reflections from $AlPO_4$-cristobalite constitute a pattern identical with that obtained by heating wavellite ($Al_3(PO_4)_2(OH)_3.5H_2O$) to 950 C (Blanchard, 1968). X-ray patterns of crandallite heated to

successively higher temperatures between 600° and 980° show increasing intensity of the lines for apatite and especially the $A1PO_4$-cristobalite (Fig. 3). From this it appears that the exothermic reaction at 690°, 790°, and 930° are produced by crystallization or recrystallization of apatite and $A1PO_4$-cristobalite.

The variety of apatite which develops from the heating of crandallite is uncertain. Hydroxyapatite would be expected from consideration of the materials available and is supported by the TGA which shows that the approximate fraction of original water in the system which is required to form hydroxyapatite is in fact retained in the system after dehydration and destruction of the crandallite. Measured lattice constants for the apatite are $a_0 = 9.382$ and $c_0 = 6.896$. Accepted valves for hydroxyapatite are $a_0 = 9.43$ and $c_0 = 6.88$ and for fluorapatite are $a_0 = 9.35$ and $c_0 = 6.87$. Substitution in the apatite structure and/or position of the negative ion along the 6-fold axis could account for the difference between the observed lattice constants and the accepted values for hydroxyapatite.

The x-ray pattern of crandallite heated to 1100° shows, in addition to the phases present at lower temperature, α-Al_2O_3 (corundum), and at higher temperatures the intensities of the corundum lines become progressively stronger (Figs. 2 and 3). At 1150° the reflections from $A1PO_4$-cristobalite are stronger and reflections corresponding to β-tricalcium phosphate (whitlockite) appear (Figs. 2 and 3). Finally, after heating to 1180° the x-ray pattern shows apatite (weaker than at lower temperatures), $A1PO_4$-cristobalite, corundum, and whitlockite (Fig. 3). Consideration of the changes in phases above 1100 C suggests that the general but irregular rise (exothermic) of the thermogram between 1070°-1150° results from an unresolved combination of crystallization of corundum; recrystallization of $A1PO_4$, and dehydration of apatite and conversion to whitlockite. In order to obtain a more complete x-ray pattern for positive identification of whitlockite a sample of crandallite was heated in a separate furnace to 1250 C for one hour. The x-ray pattern for this material showed a mixture of corundum, $A1PO_4$, and whitlockite, with no apatite. The lines attributed to whitlockite check well with the data of A.S.T.M. card #9-169, but there are slight discrepancies in the d-spacings (systematic) and in relative intensities. The d-spacings for corundum in the same pattern are very close to those of α-$A1_2O_3$ (A.S.T.M. card #10-173) and there-

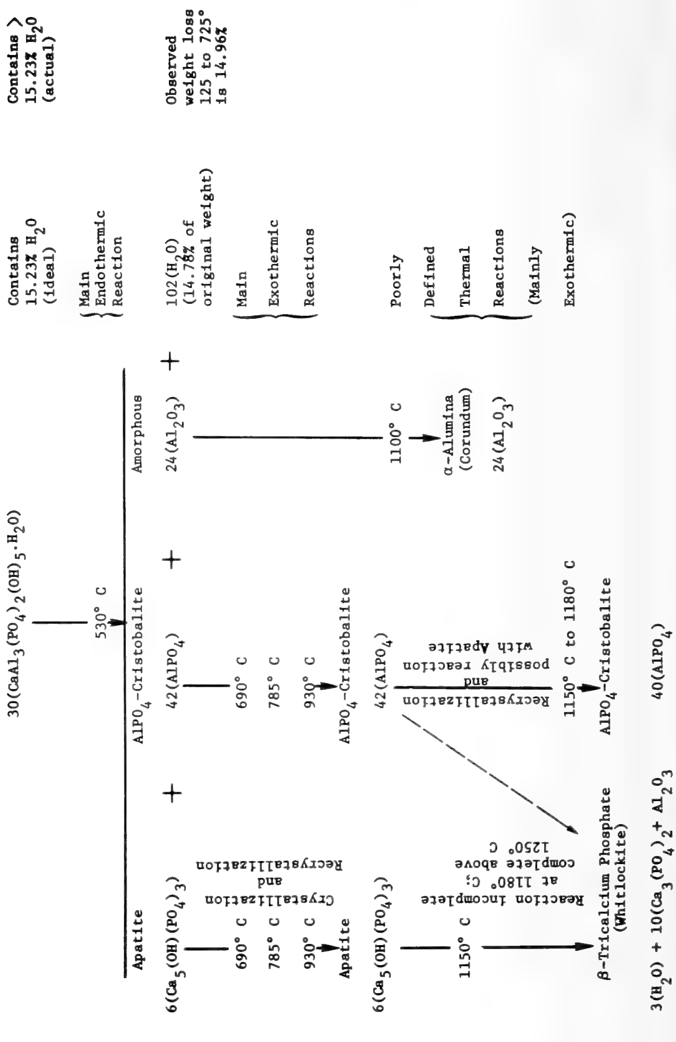

Fig. 4. Diagram of reactions occurring during differential thermal analysis of crandallite.

fore, the slight discrepancy in the whitlockite pattern is probably not due to experimental error.

Fig. 4 summarizes the changes which take in crandallite during differential thermal analysis to about 1200 C.

ACKNOWLEDGMENTS

Refinement of lattice constants was carried out through facilities of the University of Florida Computing Center.

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Prostatic Carcinoma: Histologic Grading and Metastasis

John C. Gallagher

The purpose of this study is to evaluate the possibility that certain histologic features of human prostatic adenocarcinoma correlate with the ability of the tumor to metastasize to other organs.

Materials and Methods

This study was based on 41 individuals with biopsy and autopsy evidence of adenocarcinoma of the prostate gland. The patients were among a group of 1450 consecutive patients who came to autopsy at the Veterans Administration Hospital in West Haven, Connecticut. They had been treated with chlorotrianisene, an estrogenic compound, after the clinical and biopsy diagnoses had been established. The clinical charts, autopsy records, and the biopsy and autopsy histologic sections were reviewed in each case for this study.

Tumors were graded using histologic features. Three grades were used. The best differentiated tumors mimicked the pattern of prostatic glandular structures most closely and formed small atypical ducts; these were called grade 1 tumors (Fig. 1). Grade 2 tumors were those with a cribriform (sieve-like) pattern (Fig. 2). Grade 3 tumors consisted of solid sheets of tumor cells with no ductal or glandular patterns (Fig. 3). In all grades of tumor, nucleoli were prominent in the nuclei, and at least one focus of perineural invasion was found in each primary tumor.

Grading was performed twice on all autopsy specimens of the primary tumors and metastases. It was done four times on each biopsy specimen. Grading was done after random sorting of all of the slides, without knowledge of the case identification number or of the grade assigned to other portions of the tumor of the same patient.

Results

Grading of the tumors was remarkably constant. In no instance was a tumor that had been called a grade 1 tumor called a grade 2

Fig. 1. Grade 1 adenocarcinoma of prostate. Single layer of atypical cells forms the duct-like structures. Hematoxylin and eosin stain, × 400.

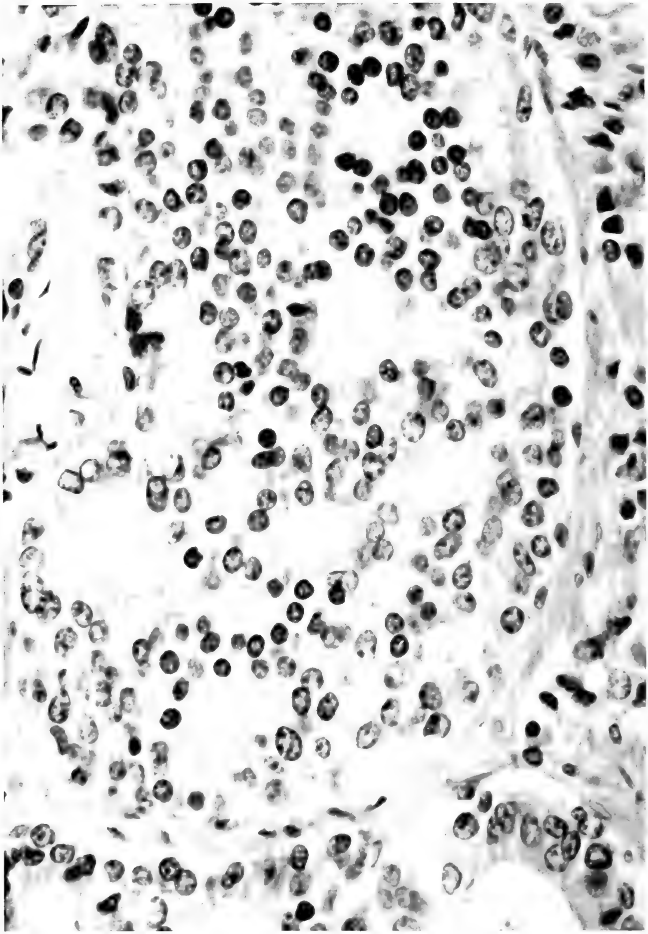

Fig. 2. Grade 2 adenocarcinoma of prostate. Cribriform pattern. Hematoxylin and eosin stain, × 400.

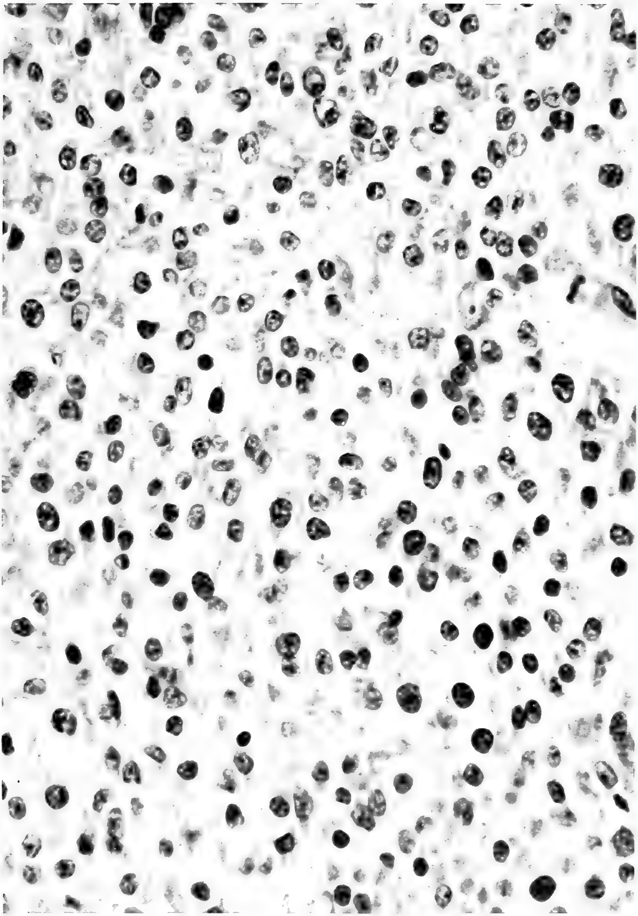

Fig. 3. Grade 3 adenocarcinoma of prostate. Solid pattern. Hematoxylin and eosin stain, × 400.

TABLE 1

Metastasis and histologic grade of tumor

Grade of tumor	Number of patients without metastasis	Number of patients with metastasis	Total
1	18	0	18
2 & 3	5	18	23
Total	23	18	41

Chi-square, 25; p, less than 0.001.

or a grade 3 tumor, or vice versa. In a given patient, the grade of tumor was remarkably constant, both for the primary tumor and the metastases. Even subtle features of the primary tumor, such as nuclear size and amount of necrosis of cells, were reproduced in the metastases.

Metastatic carcinoma was found in 18 patients, 44 per cent of the total. The lungs were involved in 13 patients, the liver in 11, bones in 10, the bladder in 9, lymph nodes in 9, the rectum in 3, the spleen in 2, and the brain, pancreas and thyroid in one patient each. In none of these organs was the pattern of the metastases different from that of the primary tumor.

An association was found between the histologic grade of the primary tumor and the presence or absence of metastases (Table 1). Grade 2 and grade 3 tumors behaved similarly and were grouped together for the purpose of this study. Grade 1 tumors in these patients did not establish distant metastases; of the grade 2 and grade 3 tumors, 78 per cent established distant metastases.

No difference existed between the ages of patients with grade 1 tumors and grades 2 and 3 tumors. The median age of the entire group was 68 years. For patients with grade 1 tumors it was 69 years; for patients with grades 2 and 3 tumors it was 66 years. A chi-square test on the distribution of ages in the two groups revealed no statistically significant difference.

The duration of survival from the onset of symptoms varied considerably among the patients. Accurate data was available for only half of the group, and no statistically significant difference could be shown with respect to grade of tumor. For the 20 patients on whom data is available, the median survival period was 24 months. For patients with grade 1 tumors it was 31 months, and for those with grade 2 and grade 3 tumors it was 9 months. These data sug-

gest decreased longevity for the patients with grades 2 and 3 tumors, but the ranges were so wide that no statistically significant difference could be shown. Survival data is complicated by the fact that the majority of patients died as a result of causes other than their prostatic carcinoma. Only 13 (32 per cent) of the entire group died as a result of this tumor. The remaining 68 per cent died from causes such as myocardial infarction, cerebral hemorrhage, pulmonary thromboembolism, cirrhosis of the liver, pneumonia, or other malignant tumors.

Discussion

This study shows an association between the histologic grade of adenocarcinoma of the prostate and the ability of the tumor to establish metastases. Tumors of the well differentiated pattern that formed ductal structures, the grade 1 tumors, failed to metastasize, whereas the non-ductal tumors, the grade 2 and grade 3 tumors, frequently metastasized. The morphologic pattern of a prostatic adenocarcinoma is an important index of its ability to produce metastases.

Other studies have shown that there is evidence that the histologic grade of tumor correlates with the length of survival of the patients. Muir noted this in 1934, and more recently Bauer et al. and Mellinger et al. have added supporting data. However, the majority of patients with this disease die from other causes, as shown in this study and in a study by the Veterans Administration Cooperative Research Group. Survival data alone give a less direct measure of the behavior of the tumor than do data on the ability to metastasize.

The histologic grade of a given prostatic adenocarcinoma gives an index of its ability to metastasize during therapy with estrogen. Thus, histologic grading has a prognostic significance. Tumors that form simple ductal structures tend not to metastasize; those with non-ductal, cribriform or solid patterns tend to metastasize. A difference in the biological behavior of these tumors is associated with a difference in their histologic morphology.

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Limnological Cycles in a Phosphatic Limestone Mine Lake

George K. Reid and S. Dexter Squibb

Since the early part of the 20th century "strip-mining" for land pebble phosphate matrix in south-central Florida has produced hundreds of "pits" which in time become filled with water. The greatest concentration of these lies in an area of some 6760 km^2 in Polk, Hillsborough, Manatee, and Hardee counties. The lakes produced vary in surface area, depth, and age and would, therefore, form the framework for very productive studies in comparative limnology.

To our knowledge, no intensive investigation of annual biogeochemical cycles in the phosphate pit lakes has been published. This report is a description of the limnological features and dynamics of one such lake.

Phosphate Pit Lake

The basin of Phosphate Pit Lake (27°44′N lat. and 82°00′ W. long., Polk County, Florida) is an excavation resulting from mining of limestone containing phosphate rock "pebbles." These pebbles, ranging in size from less than 0.1 mm to over 30 mm, are pale orange to dark brown carbonate fluorapatite, with minor quantities of magnesium, manganese, uranium, potassium, sodium compounds, and others. The phosphorous content of the rock is in the form of tri-calcium phosphate ("bone phosphate of lime") ranging from 66-80 per cent $Ca_3(PO_4)_2$, or from 30-35 per cent as phosphorous pentoxide, which places this among the highest grade rock in the world (Shirley and Vernon, 1960). The material is a conglomerate of pebble, sand and clay deposited during the late Miocene or early Pliocene, and termed the Bone Valley Formation for the great array of fossil vertebrates contained in it.

The lake (Fig. 1) has a shoreline of 2,043 m, and the surface area is 28 ha, giving a shoreline development index (D_L) of 2.16. (Since completion of our study, reclamation efforts have reduced the surface area by about 2.4 ha). The sides of the basin are nearly perpendicular, resulting in no littoral zone of any extent. Maximum depth is 8.8 m with a mean of 7.9. Lake surface level (37 m above mean sea level) varied only 1.3 cm during 1962. The bottom

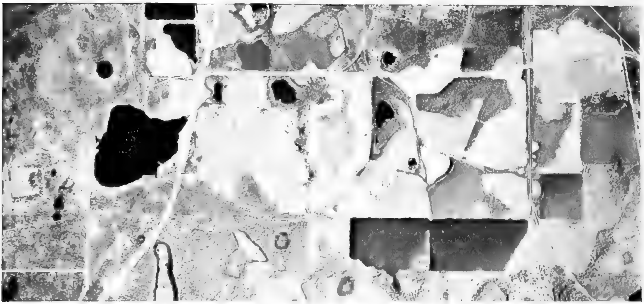

Fig. 1. Aerial photograph of Phosphate Pit Lake (extreme left) and nearby pits in 1958 (U. S. Department of Agriculture photo).

consists of very fine-grained flocculent silt (locally called "slime"), about 3 m thick, and supports no rooted plants. Natural vegetation surrounding the lake consists of forests of longleaf pine (*Pinus palustris*) and oaks; the turkey oak (*Quercus laevis*) and wire grass (*Aristida stricta*) are common. Willows (*Salix longipes*) have colonized the steep banks of the lake near the surface level. Precipitation and environmental temperature in the vicinity of the lake are shown in Fig. 2. This pit was mined during 1921, 1922, 1923 and then abandoned. It became water-filled probably within two years.

The station on Phosphate Pit Lake was occupied from 0830-1130 hr monthly during the period of study. In January, at the latitude of the lake, only one hour and thirty-five minutes of daylight prevailed before sampling was begun; in June some three and one-half hours of light had prevailed. This difference could have had some effect on certain data, particularly those pertaining to dissolved oxygen and carbon dioxide, chlorophyll, vertically migrating zooplankton, light transmission, and temperature.

METHODS

Phosphate Pit Lake was visited monthly from August, 1961, through October, 1962. One sampling station was established over the deepest part of the lake and was occupied at nearly the same clock hour on each visit.

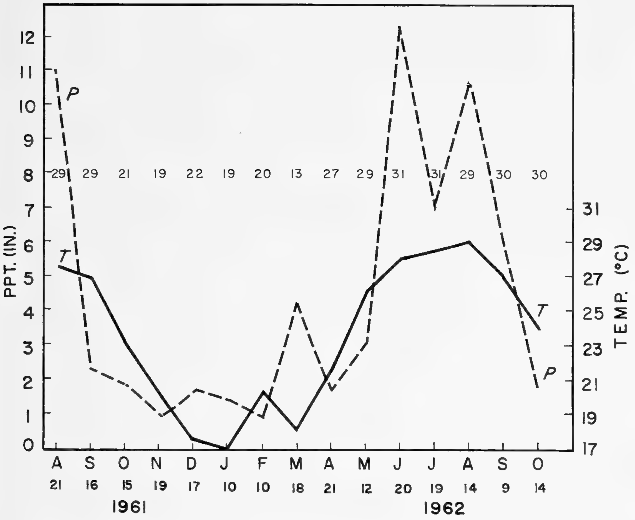

Fig. 2. Monthly mean precipitation and atmospheric temperature in the environment of Phosphate Pit Lake during 1961 and 1962. Figures inside the axes give atmospheric temperature at time of each visit. Numbers below the month abbreviations denote the date of visitation. Precipitation is given in inches following U. S. Weather Bureau policy.

All field work was done from an aluminum boat. Samples for chemical analyses were taken from the surface and at one-meter intervals to the bottom by means of a three-liter Foerst water sampler (Kemmerer-type). Samples returned to the laboratory for chemical analyses were stored in amber glass jugs that had been acid washed prior to use. Analyses in the laboratory were begun within 48 hours. Field determinations of methyl orange and phenolphthalein alkalinity, dissolved oxygen, and carbon dioxide were made immediately upon return to shore.

Chemical methods are listed below.

(1) Specific Conductance: Industrial Instrument Co., self-contained conductivity bridge with null indicator (American Public Health Association, Standard Methods, 1960).

(2) Calcium: Titrimetric with Calcein indicator and EDTA (Standard Methods, 1960).
(3) Total Hardness: Titrimetric with EDTA (Standard Methods 1960).
(4) Nitrate Nitrogen: Phenoldisulfonic acid method (Standard Methods, 1960).
(5) Magnesium: Difference in EDTA determination of Ca + Mg.
(6) Phosphate (ortho): Ammonium molybdate-stannous chloride method (Standard Methods, 1960).
(7) Aluminum: Hellige Water Comparator, color discs, and reagents from Hellige Corporation.
(8) Dissolved Oxygen: Alsterberg (Azide) modification of Winkler Method (Standard Methods, 1960).
(9) Free Carbon Dioxide: Titrimetric with NaOH and phenolphthalein (Standard Methods, 1960) and also calculated from *p*H and total alkalinity according to Rainwater and Thatcher (1960); the latter values are used in references to carbon dioxide.
(10) Total Alkalinity: Titrimetric with H_2SO_4 and methyl orange (Standard Methods, 1960).
(11) Phenolphthalein (Carbonate) Alkalinity: Titrimetric (Standard Methods, 1960).
(12) Hydronium Ion Concentration: Beckman Electric Pocket *p*H meter, replaced by Hellige Colorimetric Comparator Set with glass standards and indicators.
(13) Chloride: Mohr method (Standard Methods, 1960).
(14) Silicon Dioxide: Colorimetric molydosilicate method (Standard Methods, 1960).
(15) Iron: Phenanthroline method (Standard Methods, 1960).

Of the items listed above, (1) through (12) were determined monthly at one-meter intervals surface to bottom; items (13)-(15) were determined at 1 m intervals through the water column in August, 1961, January, April, August, and October, 1962. Because of technical difficulties, sodium and potassium were not assayed.

Physical features were measured as follows: stage data; personal gages; temperature: Whitney Electrical Underwater Thermometer, Whitney Instruments Co.; light transmission: Secchi disc and Whitney Underwater Daylight Meter with Deck Cell (Whitney Instruments Co.).

Certain biological components of the lakes were investigated and the methods are as follows.

Chlorophyll a and chlorophyll b. Acetone extraction and spectrophotometric method (Richards with Thompson, 1952, and Creitz and Richards, 1955). Absorbencies were read at 665, 645, and 630 $m\mu$ using a Bausch and Lomb "Spectronic 20" colorimeter with appropriate tubes. Samples were from one-meter intervals, surface to bottom, March-October, 1962. Banse and Anderson (1967) have found that values obtained by the Richards with Thompson equations are about 24 per cent higher than those derived by UNESCO (1966) and Parsons and Strickland (1963) procedures.

Phytoplankton. Concentrated from a 1.5-liter preserved sample of lake water by centrifuging at a moderate rate in a Foerst centrifuge. Aliquots of the concentrate were counted in a Sedgwick-Rafter cell at 100$\times$ magnification with a Whipple micrometer disc. From 5-10 fields were counted, depending upon density of organisms. In some instances, a total count of the entire contents of the cell was taken.

Zooplankton. Collection was monthly by means of a 10-liter plankton trap (Juday type) with a net of No. 25 bolting silk. Generally, samples were taken at the lake surface, mid-depth, and just above the bottom. In a number of instances, however, samples were taken at one-meter intervals, surface to bottom. In most determinations, total counts of zooplankton in a concentrated sample were made rather than estimation from aliquots.

Benthic organisms. Collection was monthly by means of a 6"$\times$6" (15.2$\times$15.2 cm) Ekman sampler at each station. The dredged material was washed over graded screens of mesh size sufficient to retain insect larvae and pupae, oligochaetes, and larger animals. Generally, two samples were screened at each station.

Total seston. Estimation was made by centrifuging 1.5 liters of lake water in a Foerst centrifuge and drying the centrifugate in an oven at 70° C for approximately 24 hours, or until quantitatively consistent weights taken 1-2 hours apart were obtained.

PHYSICAL AND CHEMICAL CHARACTERISTICS

Temperature. Phosphate Pit Lake was thermally stratified in

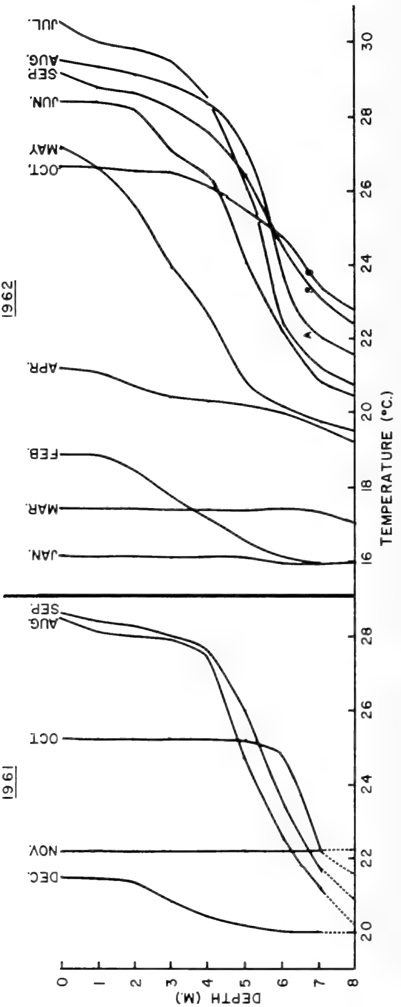

Fig. 3. Annual temperature cycle of Phosphate Pit Lake.

August, 1961, when the present study was begun, and remained so until October. Cooling began in August both years. The column was isothermal, or nearly so, from November, 1961, until May, 1962, when stratification was reestablished (Fig. 3). Lowest temperatures recorded were in January, at which time the water was almost uniformly 16 C surface to bottom. Surface waters were warmest in July, 1962, when the temperature reached 30.5 C. The mean ($N = 15$) surface temperature was 24.7 C. The range of bottom temperatures was much more narrow than that at the surface; at a depth of 7.5 m the minimum temperature was 15.9 C recorded in January and February, 1962, and the maximum was 22.7 C in October, 1962. The mean temperature at 7 m during the 15 months was 20.4 C.

The anomolous water temperature patterns of February and March, 1962, rest upon local climatological conditions. The average atmospheric temperature in the vicinity of the lake in February was 20 C, about 3° above normal, while the average for March was 17 C, or about 1° below normal (U. S. Dept. Commerce, 1963, pp. 174-183). Our data show that the air temperature at the time of our February visit was 20 C; in March it was 13 C.

On the basis of the vertical distribution patterns of oxygen and various ions described subsequently, and of temperature patterns shown here, we are led to conclude that this lake exhibits a high level of stability when stratified. The data show one circulation a year in winter and thus would qualify the lake as "warm monomictic" (Hutchinson and Löffler, 1956), although, admittedly, the hypolimnion is not extensive.

Transparency. The waters of Phosphate Pit Lake are generally turbid throughout the year. Secchi disc transparency was lowest during winter months and highest in summer (Fig. 4), the range being from 33 cm in February, to 110 cm in June, 1962. As pointed out previously, these measurements were made at roughly the same clock hour (0830-0930 hr) each month and the angle of incident radiation was greater in summer than in winter; a hazy overcast is also often present in the early hours of winter months.

Although measurements with the underwater light meter were taken only from February through October, 1962, there appears to be substantial agreement between these data (Table 1) and Secchi disc readings. Indeed, responses of the deck cell of the unit indicated that incident surface radiation at the time of the February-

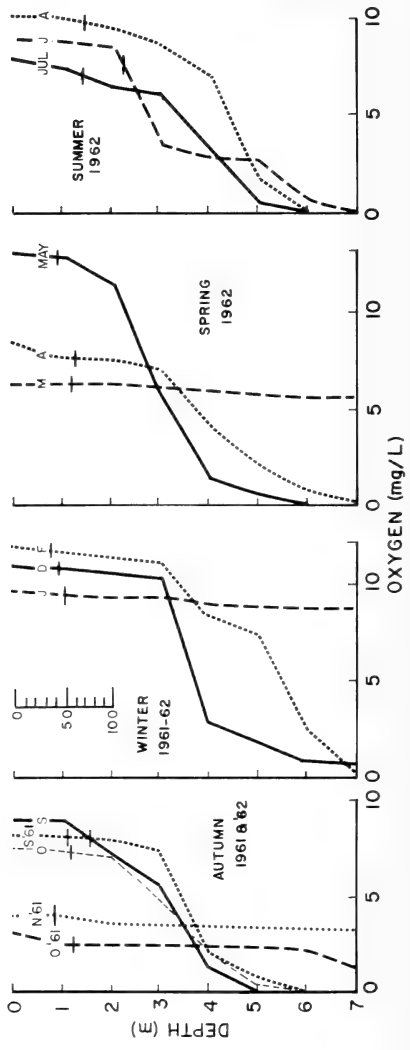

Fig. 4. Monthly patterns of dissolved oxygen content and Secchi disc readings through the water column of Phosphate Pit Lake. Cross bars on the graphs denote Secchi disc readings in cm in depth referable to the scale inset in coordinates for Winter.

TABLE 1

Light transmission, as per cent of surface illumination, through Phosphate Pit Lake, February-October, 1962

Depth (m)	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct
1	1.4	4.7	7.2	4.8	28.4	11.8	10.2	3.8	3.7
2	0.0	0.6	2.0	0.6	10.4	3.8	2.6	0.2	0.2
3		0.0	0.6	0.0	4.3	1.0	0.4	0.0	0.0
4			0.0		1.4	0.4	0.1		
5					0.5	0.1	0.0		
6					0.2	0.0			
7					0.0				

March visits was about 33 per cent of that in summer. The greatest depth at which light was measured was 6 m; this was in June, when 0.2 per cent of the surface intensity was transmitted to that depth. The mean attenuation at a depth of 1 m during the period of study was 8.4 per cent of surface light.

Specific Conductance and Total Hardness (EDTA). Specific conductance, expressed as micromhos (reciprocal megohms) per cm at 25 C (μmhos), is proportional to the total electrolytes in water and serves as a quick introduction to the combined aspects of anions and cations in Phosphate Pit Lake. The reacting weight of each ion, milligram equivalents per liter (me/liter), can be obtained by multiplying the concentration of a given ion (mg/liter or ppm) by the reciprocal of its combining weight.

The mean of all conductance measurements made monthly at 1 m intervals of depth (N = 119) during the 15-month study was 77 μmhos. Lowest conductance was in late summer and early autumn, 1961 and 1962, near the surface and at mid-depth (3-4 m) with values from 56-60 μmhos (Fig. 5). Highest ionic concentrations occurred during summer and early autumn in the near-bottom strata when in August, 1962, conductance reached 140 μmhos at 7 m, during a pronounced stratification. This developed in May, 1962, and existed into October, being a reflection of the vertical distribution of calcium and carbonate ions described below. During the period October, 1961-May, 1962, conductance was generally uniform from surface to bottom. The means of measurements made through the water column (N = 8) monthly ranged from a high of

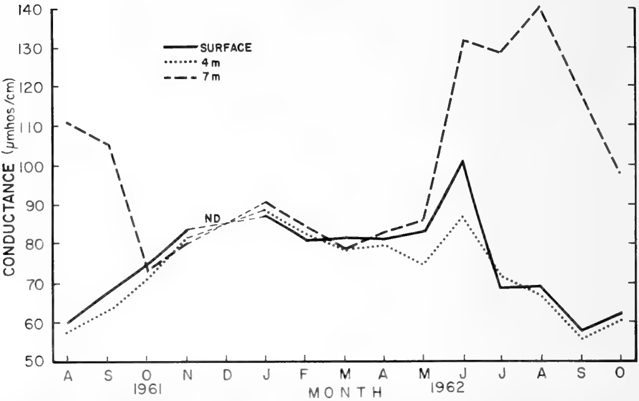

Fig. 5. Specific conductance monthly at surface, near-mid-depth (4 m), and bottom (7 m).

104 μmhos in June, 1962, to a low of 71 μmhos four months later in October.

Hardness (EDTA as mg/liter $CaCO_3$) varied from 47 at 7 m depth in July, 1962, to 17 mg/liter two months later at 4 m. The mean of all measurements ($N = 120$) was 28 mg/liter. The vertical distribution pattern of hardness exhibits, of course, the late summer-early autumn extreme highs correlated with conductance in the deeper waters and approximates bicarbonate alkalinity throughout. Noncarbonate hardness was present above 6 m depth at all times but disappeared from the bottom one-meter during the periods of high conductance and total hardness. Seasonal noncarbonate hardness at three depths is given in Table 2.

Alkalinity. Alkalinity was measured as methyl orange ("total") alkalinity, due to bicarbonates, and as the phenolphthalein equivalent of carbonate. Total alkalinity of the lake waters ranged from 70 mg/liter (1.15 me/liter) in July at 7 m, to 10 mg/liter (0.18 me/liter) at the surface in September, 1962. The mean total alkalinity in surface waters was 20; at 3 m it was 20; and at 7 m: 39 mg/liter. From November through April the water column was generally homogeneous in terms of total alkalinity, but with the onset of

TABLE 2

Monthly values of non-carbonate hardness (total hardness minus total alkalinity in mg/liter) in three levels of Phosphate Pit Lake

Month	Surface	4m	7m
Aug	4	5	0
Sep	8	7	0
Oct	5	5	5
Nov	1	1	2
Dec	3	2	0
Jan	4	3	5
Feb	5	5	0
Mar	2	2	1
Apr	6	6	4
May	8	7	0
Jun	5	6	0
Jul	8	6	0
Aug	6	3	no data
Sep	7	6	0
Oct	5	3	0

thermal stratification in May and continuing through October, total alkalinity below depths of 4-5 m increased greatly (Fig. 6).

Carbonates were detected in the upper 3 meters of the lake in August-September 1961, and in February and April-August, 1962 (Fig. 7). The February occurrence is interesting in that it correlates with the development of a slight thermal stratification in that month, but both disappeared the following month. The seasonal appearance and vertical pattern of carbonates in this lake are similar to the conditions in Lake Providence, Louisiana (Moore, 1950). Maximum carbonates came about in May when surface waters contained 15 mg/liter (0.51 me/liter) but this concentration decreased rapidly with depth to zero at 4 m. As will be shown subsequently, that was also the month of highest *p*H readings, oxygen concentrations, and chlorophyll *a* content. The mean carbonate content, when present, in surface waters was 5 mg/liter; at 3 m: 2 mg/liter.

Hydronium Ion Concentration. The *pH* of surface waters varied from 7.4 in March, to 9.6 in May, 1962, the mean throughout the 15 months being 8.4. At approximately mid-depth (4 m) the variation was not so great, being from 7.0-8.6 with an annual mean of 7.5. As shown in Fig. 8, this region was one of considerable decline

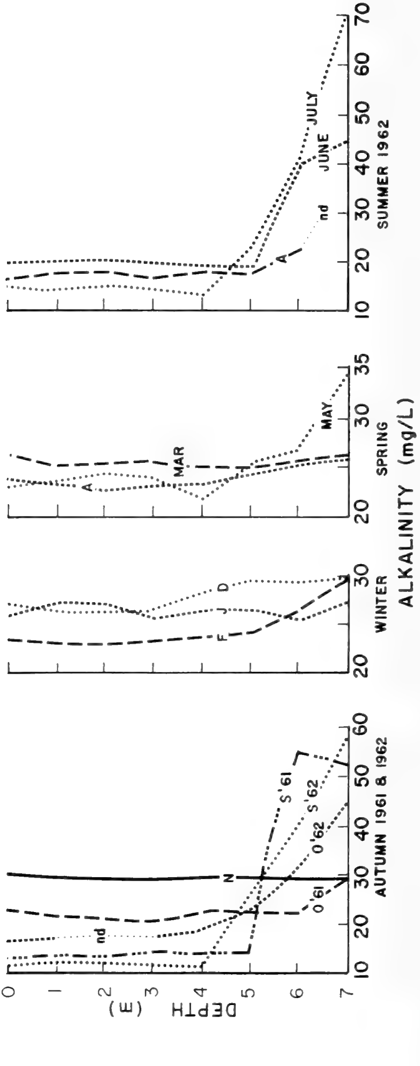

Fig. 6. Total alkalinity, monthly through the water column of Phosphate Pit Lake.

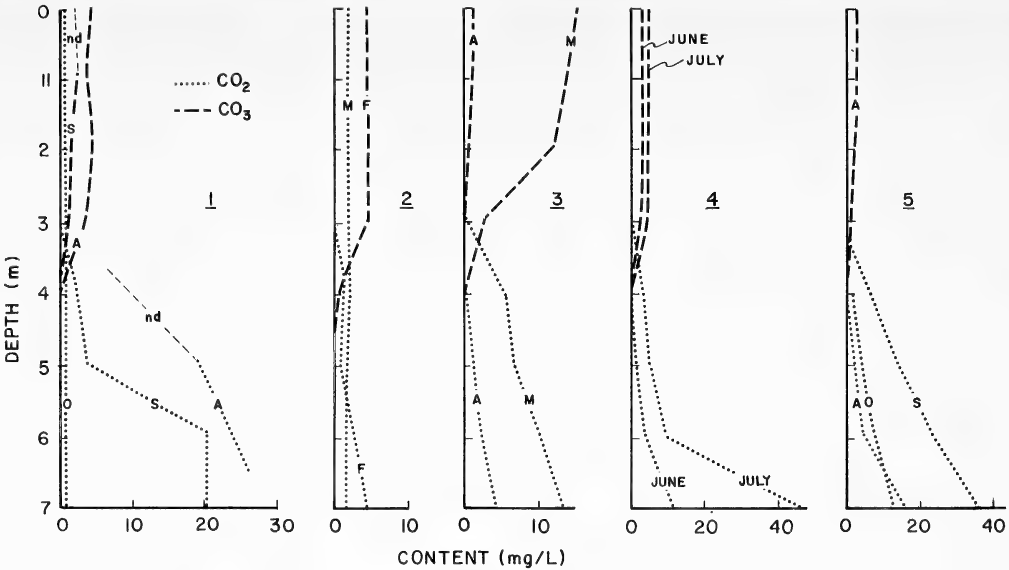

Fig. 7. Relationships of carbonate and carbon dioxide through the water column in selected months. Frame 1: August and September, 1961. Frame 2: February and March, 1962. Frame 3: April and May, 1962; Frame 4: June and July, 1962. Frame 5: August, September, and October, 1962. Values are in mg/liter.

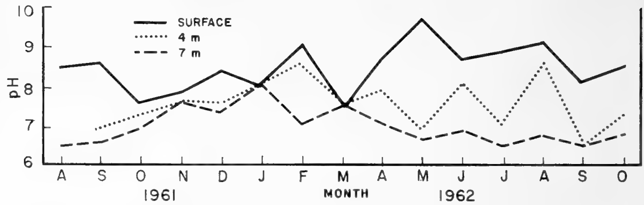

Fig. 8. Monthly variation in *p*H in three levels of Phosphate Pit Lake.

in *p*H toward more acid bottom waters which existed most of the time. The mean *p*H near bottom (7 m) was 6.9, ranging from 6.4-8.0; the high occurred in January, which was the only time the bottom layers were not at or below neutrality. Only in November, 1961, January, and March, 1962, was the water column found to be homogeneous or nearly so in terms of *p*H.

Free Carbon Dioxide. The carbon dioxide content in the upper 3 m of the lake was less than 1 mg/liter at all times except in March, 1962, when values of 1.6 mg/liter were obtained at all levels through the water column. From 4-7 m depth, however, considerable variation was found seasonally both at a given depth and in vertical perspective (Fig. 7). Highest concentrations of carbon dioxide were at 7 m in August and September, 1961, and during July and September, 1962; in the latter two months the values were 44 and 36 mg/liter respectively. Vertically, the waters were homogeneous and contained less than 1 mg carbon dioxide/liter at all depths in October-November, 1961, in January, 1962, and nearly so in December, 1961, there being only 3 mg/liter difference from surface to bottom. The mean carbon dioxide content at 4 m depth was 1.9, and at 7 m, 12 mg/liter.

Dissolved Oxygen. During the 15-month period, dissolved oxygen in the uppermost meter of the lake varied 9.9 mg/liter. From a low of 2.8 mg/liter (34 per cent saturation) in October, 1961, the concentration reached a high of 12.7 mg/liter in May, 1962. Surface waters failed to reach saturation during the periods September-November, 1961, and March-April, 1962. The mean concentration (N = 15) of oxygen in surface waters was 8.4 mg/liter. Near mid-depth at 4 m, concentrations of 1.3-7.0 mg/liter prevailed, the mean of the monthly measurements being 4.1 mg/liter. Below 6 m depth anaerobic conditions existed in August and September, 1961, and

from May through October, 1962. At 7 m the oxygen concentration was 8.7 mg/liter in January and 5.5 mg/liter in March, but throughout the other months it was less than 3 mg/liter, the mean for all months being 0.9 mg/liter.

Vertically through the lake the dissolved oxygen content was homogeneous, or nearly so, only in October and November, 1961, and in January and March, 1962 (Fig. 4). During the other months, marked oxygen stratification existed, and in some instances exhibited rather dramatic declines in concentration over a short vertical distance. In September, 1961, for example, the oxygen content decreased 5.1 mg/liter from 3-4 m; and in December the decline was 7.7 mg/liter in the same stratum. In May, 1962, the oxygen decreased 5.5 mg/liter between 2-3 m of depth. Moore (1950) reported similar phenomena in Lake Providence, Louisiana, and emphasized that the rapid decline in oxygen often occurred above the thermocline, as was also the case in Phosphate Pit Lake (Fig. 4). Moore suggested that such conditions would indicate incomplete mixing at times in the epilimnion as a result of protection from winds. The small surface area and the steep banks surrounding the pit would tend to reduce wind effects.

Calcium and Magnesium. The calcium content of the lake waters fluctuated seasonally, both at any given depth and vertically with considerable magnitude. Minimum concentration of the ion (8.8 mg/liter) was in September, 1962, at 4 m, while the maximum (34.9 mg/liter) existed at the same time at 7 m. As shown in Fig. 9, calcium was lowest in surface waters in summer and remained rather uniformly near 20 mg/liter during the remainder of the year. The mean of 15 surface determinations was 16.3 mg/liter (0.79 me/liter). Generally, the amounts of calcium seasonally at mid-depth varied little from those near surface, the mean at 4 m being 15.8 mg/liter. During summer and early autumn, however, concentrations were increased greatly below 5 m resulting in a mean of 24.8 mg/liter (1.21 me/liter) at 7 m. From October, 1961, through May, 1962, the calcium content of the lake was nearly uniform from surface to bottom (Fig. 9), but during summer, differences through the water column varied about 15.5 mg/liter, and in September, 1962, 24.6 mg/liter from surface to 7 m.

Magnesium concentration varied only from 7.0 mg/liter in March 1962, at 4 m to 15.0 mg/liter recorded the previous Septem-

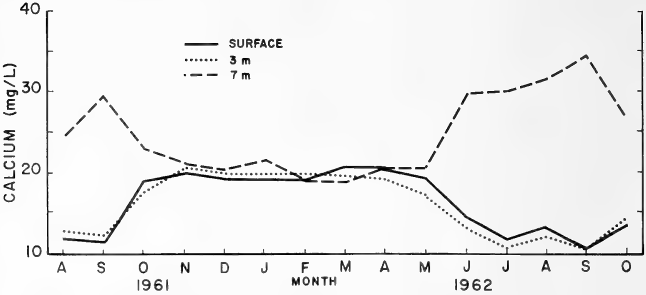

Fig. 9. Seasonal variations in calcium content in three levels of the lake.

ber. The magnesium maximum in surface waters was 12.6 mg/liter in May, 1962, the minimum being 7.7 mg/liter in March preceding. The mean magnesium content of the surface stratum (N=15) was 9.9 mg/L (0.81 me/liter); the mean at mid-depth was approximately the same. At 7 m magnesium ranged from 7.9 mg/liter in March, 1962, to 17.2 mg/liter the following July. The mean of monthly measurements at that depth was 11.7 mg/liter (0.95 me/liter) reflecting slightly higher concentrations in late summer than during the remainder of the year.

Aluminum, Silica, Iron, and Chloride. Although analyses were made monthly over the 15-month period, aluminum was detected only in September-October, 1961, February-March, and May-June, 1962. The highest concentration was 0.09 mg/liter in the bottom 2 m in February; this was the only period when the ion was found at all depths, the mean through the water column being 0.05 mg/liter (0.005 me/liter). The mean of all detectable quantities (N=34) was 0.03 mg/liter.

Analyses for silica (as SiO_2) were made in August, 1961, and in January, April, August, and October, 1962; the ion was present at all depths in each of the months. Highest concentrations in surface waters, as well as through the vertical column, were in January (Table 3), the mean through the column in January was 4.0 mg/liter. Greatest amounts in deep waters were in August, 1961 and 1962. The mean of surface waters was 2.7 and at 7m, 3.4 mg/liter. Lowest quantities occurred in October, 1962, at which time the

TABLE 3

Silica, iron, and chloride (mg/liter) in Phosphate Pit Lake in August, 1961, and in January, April, August, and October, 1962

Mineral	Depth (m)	Aug	Jan	Apr	Aug	Oct
SiO_2	0	2.4	4.9	2.9	2.1	1.3
	1	3.2	4.9	2.7	2.3	1.1
	2	2.8	3.5	2.8	2.0	1.1
	3	2.5	3.5	2.8	2.5	1.2
	4	2.4	3.9	2.5	1.8	1.1
	5	2.2	3.9	2.9	2.0	1.4
	6	2.2	3.9	3.0	2.2	1.4
	7	4.1	3.8	3.3	4.2	1.7
Fe	0	0.05	0.12	0.07	0.10	—
	1	0.08	0.11	0.07	0.10	—
	2	0.09	0.04	0.07	0.09	—
	3	0.08	0.03	0.04	0.09	—
	4	0.04	0.03	0.07	0.09	—
	5	0.03	0.04	0.04	0.09	—
	6	0.06	0.01	0.04	0.12	—
	7	0.17	0.02	0.04	0.26	—
Cl	0	8.5	7.3	8.5	6.2	5.7
	1	8.9	7.5	7.5	6.4	6.2
	2	8.5	7.5	8.3	5.8	6.2
	3	8.8	7.8	7.8	7.0	6.2
	4	8.4	7.6	7.0	6.4	5.6
	5	8.3	7.8	7.1	6.0	6.2
	6	8.3	8.0	8.0	6.6	5.7
	7	8.5	7.9	7.1	—	5.3

column mean was 1.3 mg/liter. The mean of all determinations ($N=40$) was 2.6 mg/liter.

Iron was determined through the water column in August, 1961, and in January, April, and August, 1962. In surface waters the iron content ranged from 0.05 mg/liter in August, 1961, to 0.12 mg/liter in January following (Table 3); the mean ($N=4$) at the surface was 0.08 mg/liter. Near bottom, the mean iron concentration was 0.12 mg/liter, resulting mainly from decidedly higher values obtained in August, 1961 (0.17 mg/liter) and again the following August (0.26 mg/liter). Vertically, the amount of iron was highest in August, 1962, at which time the mean of eight analyses was 0.12

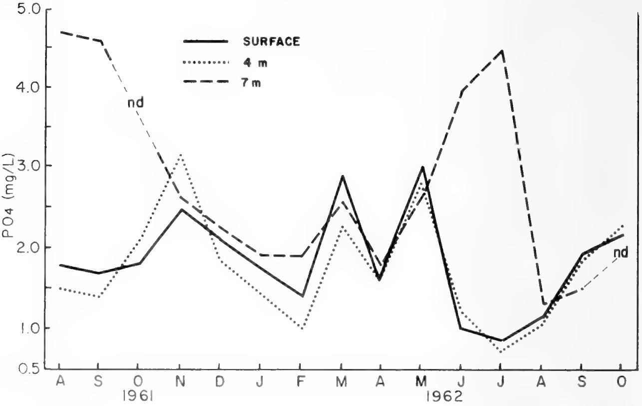

Fig. 10. Seasonal variations in orthophosphate content in three levels of the lake.

mg/liter. In August preceding, however, the mean through the column was 0.07 mg/liter, while the January and April means were 0.05 mg/liter in each of the months. The mean of all determinations (N=32) was 0.07 mg/liter.

Chloride was measured in August, 1961, and in January, April, August, and October, 1962. Greatest concentration through the column occurred in August, 1961 (Table 3), when the mean was 8.5 mg/liter. The lowest vertical content was in October, 1962, the mean being 5.9 mg/liter. Seasonally, chloride varied little with depth, the mean for surface waters amounting to 7.2 mg/liter; at 4 m: 6.6; and at 7 m: 7.2 mg/liter. The mean of all measurements (N=39) was 7.2 mg/liter (0.20 me/liter).

Orthophosphate and Nitrate. The highest concentrations of phosphate (ortho) in the lake were detected in August-September, 1961, and in June-July, 1962, when values from 4.0-4.7 mg/liter were obtained. Minimum quantities were found during the period June-August, in the upper 4 m, the range being 0.7-1.1 mg/liter. The mean of all determinations (N=119) for phosphate was 2.0 mg/liter. Throughout the 15-month study, the phosphate content in surface and mid-depth waters differed little (Fig. 10), the mean for each stratum being 1.8 mg/liter. In the zone below 6 m, how-

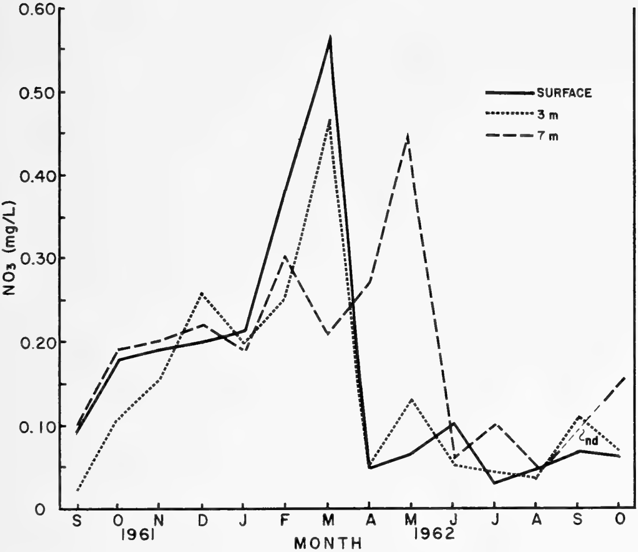

Fig. 11. Seasonal variation in nitrate content at three levels in Phosphate Pit Lake.

ever, the concentration varied considerably from 1.1 mg/liter to the maxima noted above. The mean content through the seasons at 7 m was 2.7 mg/liter. Through the water column, the lake waters were richest in phosphate in May, the mean from surface to bottom being 3.1 mg/liter. Three months later, however, this had decreased to 1.2 mg/liter.

Nitrogen as nitrate fluctuated considerably both vertically from month to month (Fig. 11) and seasonally at the various depths. The highest values through the water column were taken in March, 1962, when the surface waters contained 0.57 mg/liter and the deeper water 0.21 mg/liter, the mean being 0.39 mg/liter. Minimum concentrations occurred in July and August, 1962, at which times the mean for each month was 0.04 mg/liter. Surface waters varied from a high of 0.57 mg/liter in March, 1962, to 0.03 mg/liter the following July, the mean for 14 months being 0.15 mg/liter. The

mean for the same time at a depth of 4 m was 0.13 mg/liter. Deeper waters, at 7 m, contained somewhat higher quantities of nitrate, the mean being 0.18 mg/liter.

BIOLOGICAL CHARACTERISTICS

Phytoplankton. Data on phytoplankton are available for the period August, 1961, through August, 1962. The most persistent algae during this period were blue-greens, *Anacystis* sp. and *Anabaenopsis* sp., the former being present from surface to bottom at all times but showing no particular seasonal pattern in variation in density. *Anabaenopsis* was not recorded in January, 1962, and concentrations were generally low during the winter months. In late summer, however, the density reached 270×10^5 filaments per liter in 1961 (August) and 110×10^5 filaments/liter in August, 1962. Another blue-green, *Chroococcus* sp., was present from August through December, 1961, reaching maximum density of 8.5×10^5 cells/liter in the latter month at a depth of 7 m.

The most conspicuous Chlorophyta in Phosphate Pit Lake were *Ankistrodesmus falcatus* var. *spirilliformis* G. S. West, *Scenedesmus* sp., *Tetraëdron* sp., and *Coelastrum sphaericum* Naeg. The occurrence of *Ankistrodesmus* appeared to be decidedly seasonal, for it was present in August, 1961, in concentrations of 1300×10^5 cells/liter at the surface and 3300×10^5 cells/liter at 4 m, but was not recorded again until the following May. In that month the count was 83×10^5 cells/liter in surface waters and it increased to 230×10^5 in July. By August the density in surface waters decreased to 150×10^5 cells/liter. During the summer months the count of *Ankistrodesmus* decreased directly with depth such that at 7 m the population ranged from 11×10^5 to 70×10^5 cells/liter. *Scenedesmus* sp. was present through the water column in October and December, 1961, and from February through June, 1962. In the surface waters the concentration of the alga ranged from 4.1×10^5 cells/liter in December, to 0.5×10^5 cells/liter in June; at a depth of 7 m the lowest counts were 0.7×10^5 in February and June, and the highest, 7.6×10^5, in December. The occurrence of *Tetraëdron* coincided with that of *Ankistrodesmus* but continued later through July and August, 1962. In the upper waters the lowest population density of *Tetraëdon* was 0.3×10^5 cells/liter in April, while the highest was

12×10^5 in July following. Generally, the density of the alga decreased with depth such that counts at 7 m ranged from 1.3×10^5 to 3.9×10^5 cells/liter. *Coelastrum sphaericum* was present in our samples in November, 1961, and during April-June, 1962, although absent in surface waters during May and June. The highest concentration of the species was recorded at 4 m in April, 1962, the count being 22×10^5 colonies (coenobia)/liter.

Diatoms (Chrysophyta), mostly *Synedra*, but some *Navicula*, were present in the lake at all depths throughout the year, although the density of the aggregations varied greatly. Autumn seemed to be the season of most sparse populations; at this time our counts were of the order of 0.18×10^5 to 2.1×10^5 cells/liter. During the summer, however, diatom concentrations increased decidedly, up to the order of 5.9×10^5 to 12×10^5 cells/liter, with a maximum being reached in June, 1962, when the density at 7 m depth was 53.8×10^5 cells/liter. This was associated with a marked increase in numbers with depth; the density in surface waters was 15×10^5 and at 4 m, 38×10^5 cells/liter. Otherwise, no distinctive depth distribution pattern of diatoms was observed. The greatest variety of phytoplankters was noted in May, 1962, at which time all of the aforementioned forms except *Chroococcus* were present.

Chlorophyll a. Estimates of chlorophyll *a* were obtained through the water column monthly from February through October, 1962. In general the greatest concentrations at all depth were in the March-May period (Fig. 12). Chlorophyll *a* in surface waters ranged from 54.6 mg/m^3 in May to 6.1 mg/m^3 the following July, the mean for nine months being 23.6 mg/m^3. Near mid-depth the content of the pigment varied from 55.6 mg/m^3 in May to 5.8 mg/m^3 in September, the mean for the period at this depth being 26.3 mg/m^3. At the bottom, the highest value (46.4 mg/m^3) was determined in May, and the lowest (3.1 mg/m^3) in February preceding; the mean at 7 m was 19.9 mg/m^3. Vertically through Phosphate Pit Lake the chlorophyll *a* content was maximum in May, when the mean from surface to bottom was 68.1 mg/m^3. Minimum concentration occurred in September, the mean through the column being 6.3 mg/m^3.

Zooplankton. The diel zooplankton of Phosphate Pit Lake was composed almost entirely of Rotifera and nauplii of Copepoda. We

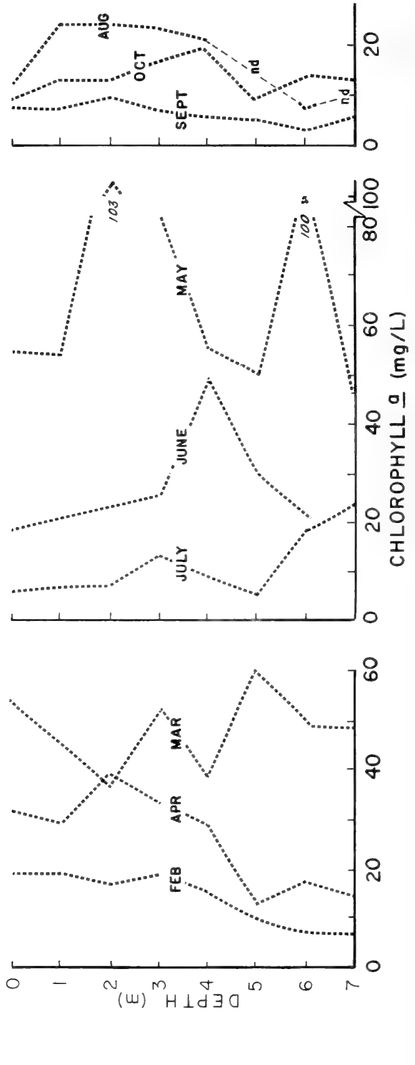

Fig. 12. Vertical aspects of chlorophyll *a* content, February through October, 1962, in Phosphate Pit Lake.

TABLE 4

Monthly counts of Rotifera (individuals per liter) at three levels in Phosphate Pit Lake

Month	Surface	3-4 m	7-7.5 m
Aug 1961	13	510	200
Sep	190	90	13
Oct	120	70	0
Nov	70	110	115
Dec	1	0	0
Jan 1962	1	1	1
Feb	90	45	0
Mar	96	160	122
Apr	6	0	0
May	563	1510	666
Jun	77	77	6
Jul	6	13	6
Aug	32	102	90
Sep	6	13	6
Oct	0	0	0

emphasize the day-time aspect, for subsequent studies of diurnal migrations of *Mesocyclops edax* in winter in a nearby phosphate pit have revealed sizable populations of this copepod, together with larvae of *Chaoborus*, from surface to bottom during early morning hours before sunrise (Reid and Blake, 1970).

The population density of rotifers varied considerably, both seasonally at a given depth and vertically within the lake (Table 4). In December, 1961, rotifers were sparse in the upper waters and absent in deeper layers; in October, 1962, no rotifers were taken in the sampling. In January, 1962, the census was only one individual per liter (ind/liter). As shown in the Table, the highest density of rotifers occurred in May, 1962, when the mid-water sample contained 1510 ind/liter; the mean of the counts at three levels was 913 ind/liter. The mean of all monthly data for surface, mid-depth, and bottom were 91, 225, and 137 ind/liter, respectively.

Copepod nauplii were present in the lake throughout most of the year although in drastically reduced numbers in summer and early fall (Table 5); none was taken at any depth in July. The mean density of the surface population for the months when the animals were present was 59 ind/liter. At mid-depth the mean was 58 ind/liter, and at bottom: 35 ind/liter.

TABLE 5

Monthly census of Copepoda (individuals per liter) at three depths in Phosphate Pit Lake

Month	Surface	3-4 m	7-7.5 m
Aug 1961	1	10	4
Sep	32	58	0
Oct	13	26	6
Nov	64	110	51
Dec	198	90	5
Jan 1962	51	76	38
Feb	134	70	45
Mar	70	90	122
Apr	83	198	77
May	0	64	70
Jun	1	6	1
Jul	0	0	0
Aug	0	1	1
Sep	0	6	1
Oct	1	2	1

Adult calanoid copepods were found in quantities greater than one per liter only from November, 1961, through April, 1962. During that period the animals were present at all depths, the maximum density occurring in December when the count in surface samples was 108 ind/liter, at mid-depth: 83 ind/liter; but only 2 ind/liter at the bottom. The mean density in the five months surface samples in which the plankter was present was 25 ind/liter; in six samples from mid-depth: 24 ind/liter; and at the bottom: 11 ind/liter.

Adult cyclopoid copepods were even more rare than calanoids in Phosphate Pit Lake. In surface waters *Mesocyclops edax* occurred only in our samples of December, 1961, and January-February, 1962; 13 ind/liter in the first period and 1 ind/liter in each of the two months of 1962. In the mid-water region this plankton was found in numbers greater than one per liter in September, October, and December, 1961, and in March, 1962; the maximum was 32 ind/liter in October. In the bottom waters we recorded more than one cyclopoid per liter only in October (13 ind/liter) and February-March, 1962 (4 ind/liter) each month. The migratory behavior of *M. edax* is apparently quite erratic, for in a 24-hour diurnal study of plankton in a near-by pit on 8 January, 1964, noon samples from 4-6 meters depth contained nine of the copepods; 12 days later the

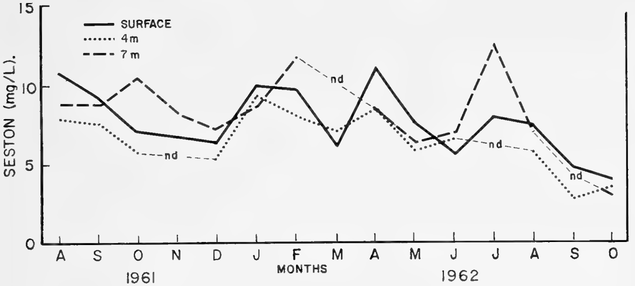

Fig. 13. Monthly variation in total seston content of Phosphate Pit Lake.

density of the species ranged from 10 ind/liter at 4 m to 27 ind/liter at 6 m (Reid and Blake, 1970).

The absence of Cladocera proved to be one of the more astounding findings in this study. At mid-depth in May, 1962, our count indicated one individual per liter, and this was the only occurrence of what is usually considered to be a characteristic planktonic crustacean. Our unpublished data for a natural lake (Scott) in the phosphate region of Central Florida reveal an identical situation, while in Clear Lake, a solution basin, cladocerans were present throughout the year in densities ranging up to nearly 400 individuals per liter.

Seston. Total seston, here defined as all living and non-living particulate matter in the water, varied in the upper waters about 6 mg/liter during the 15 months of study. The seasonal variation in seston content of bottom waters, on the other hand, was of the order of 11 mg/liter and exhibited two maxima, in February and in July, 1962 (Fig. 13). Each of these coincided with a decrease in seston mass in upper waters and followed upon noticeable pulses of seston in the upper layers. Over the 15-month period the mean seston content of surface waters was 7.6 mg/liter; at mid-depth the mean was 7.5 mg/liter; and near bottom: 8.9 mg/liter. These figure would indicate that although phyto- and zooplankton densities fluctuate through an annual cycle, as does the amount of allochthonous materials introduced seasonally with surface run-off from rainfall, the lake maintains a relatively high level of vertical homogeneity in the standing crop of seston.

Benthos. The bottom of Phosphate Pit Lake is composed of fine, flocculent material of particle size that easily washes through a screen of 20 meshes per centimeter. No macro-phytobenthos existed.

During our study, the zoobenthos of sufficient size to be retained in the aforementioned screen consisted mostly of larvae of *Chaoborus* sp. (Diptera). They were present in all months but the population density varied seasonally. The months from November, 1961, through March, 1962, were the times of greatest abundance of the larval forms, the maximum being reached in December when the count was 12,169 individuals per m^2. During the other months of the winter the density ranged from 4,000 to slightly over 5,000 ind/m^2. The population was most sparse in April, 1962, when sample counts indicated about 600 ind/m^2; this however, was also a period of emergence of the insect, and numerous exuvia were observed over the surface of the lake and on the shore.

In the diurnal studies in the near-by pit noted above, *Chaoborus* larvae became planktonic at night, appearing in the bottom two meters in January at sundown (1800 hr). By 2100 hr they were present through the entire water column and remained there until near sunrise.

The pupae of *Chaoborus* came into our samples only in September, 1961 (30 ind/m^2), February (20 ind/m^2), March (120 ind/m^2), and June (20 ind/m^2), 1962. Larval forms of another dipteran, *Tendipes* sp. were taken during winter, the highest density being 800 ind/m^2 in December, 1961. Cyclopoid and calanoid copepods were common to abundant in samples throughout the year, and small oligochaetes were taken occasionally; no quantitative estimates were made, however.

SUMMARY AND CONCLUSIONS

Phosphate Pit Lake is a small, eutrophic, monomictic body of water artificially produced as result of mining for phosphatic limestone in South Central Florida. Maximum depth to a soft flocculent bottom is 7.5-8.0 m.

Throughout the period of study (August, 1961 through October, 1962), transparency was generally low. The maximum was in June, at which time the depth at which a Secchi disc disappeared was

110 cm, and photocell measurements indicated 0.2 per cent of surface illumination at 6 m.

During the period of investigation, the lake exhibited rather stable thermal and chemical stratification from May through October, although oxygen stratification occurred in some winter months also. The hypolimnion was restricted, generally, to about the bottom-most 2 meters. During summer and early autumn, hypolimnetic waters became anaerobic, and carbon dioxide appeared in significant amounts, resulting in layering of carbonates in the upper waters and carbon dioxide in the lower strata. The quantity of dissolved substances, such as calcium, magnesium, phosphate, and bicarbonates, increased greatly in the deeper region in summer. This resulted in a decidedly higher specific conductance in the hypolimnion. Total hardness of the lake ranged about a mean of 28 mg $CaCO_3$/liter.

The nitrate content at all depths in the lake was highest during winter months, but decreased rapidly in the upper waters in spring as phytoplankton populations increased. This was followed by a marked reduction of the ion in deeper waters in June, and a low but nearly uniform nitrate content existed through the water column until autumn.

As might be expected in view of the origin and location of the lake, the phosphate content was generally high (up to nearly 5 mg/liter) but varied seasonally. During winter and spring, the concentration of this ion was rather uniform from surface to bottom, but in summer the hypolimnetic waters were much richer than the upper strata in phosphate. As shown in Fig. 14, the monthly pattern of mean phosphate through the water column exhibited trends similar to those of chlorophyll and nitrate.

The *p*H of upper waters was consistently above neutrality, becoming near and above *p*H 9 in summer. Deeper waters were nearly neutral throughout the 15-month period.

From November through April, Phosphate Pit Lake was vertically isometric, or nearly so, in total (methyl orange) alkalinity measurements, varying only slightly from near 26 mg/liter. During the remainder of the year, however, marked stratification existed and the alkalinity of strata below 4.5 m greatly exceeded that of upper waters. Carbonate (phenolphthalein) alkalinity was present in waters above 4-5 m from April through August, during which

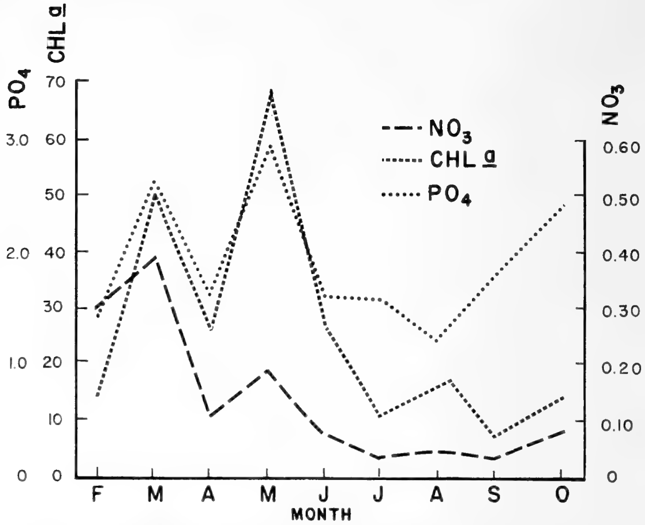

Fig. 14. Comparison of annual cycles of nitrate, phosphate, and chlorophyll *a* in Phosphate Pit Lake. Monthly values represent the mean content of each substance vertically through the water column determined at one-meter intervals, surface to bottom (7 m). All values are expressed as mg/liter.

time carbon dioxide was absent, doubtlessly having been taken up in algal photosynthesis.

Silica occurred in highest quantities in winter and decreased through spring and summer, probably being incorporated into valves of diatoms as these algae increased in number. Iron and chloride concentrations remained essentially uniform over the year.

Chlorophyll *a* was determined vertically through the water only from February through October, 1962. Highest quantities occurred in March, May, and June. In March, maxima existed at depths of 3 m and 5 m; in June, a maximum occurred at 4m; and in May, maxima were at 2 m and 6 m. Seasonally, the monthly mean chlorophyll content through the water column followed closely the pattern of phosphate and nitrate (Fig. 14).

Surface temperatures varied from 16.2 C in January to 30.5 C in July; bottom waters ranged from 15.9 C in January and February to

22.7 C in October. As indicated above, the lake was thermally stratified from May through October, and nearly homothermal during winter. All data pointed toward a rather high degree of stability during stratification.

The dissolved oxygen content of the lake was highest in May in surface waters (12.7 mg/liter). In the upper strata, the concentration failed to reach saturation in September and November, 1961, and during the period March-April, 1962. In 1961, however, stratification was not present in October, and, interestingly, oxygen stratification reappeared during winter in December and February. Throughout the summer the oxycline extended from about 2 m to near 4 m of depth. Anaerobic states prevailed below 5 m in August-September, 1961, and from May through October, 1962.

Free carbon dioxide in significant amounts was confined to waters of the lake below 4 m. Considerable season variation in the content of the gas occurred, the highest concentrations being in late summer and early autumn (up to 44 mg/liter). Vertical distributional relationships between carbon dioxide and carbonates were noted previously.

Biologically, the lake appeared to be quite productive, at least insofar as the seasonal standing crop of phytoplankton was concerned. In winter the populations were sparse, consisting predominantly of *Anacystis* sp., *Anabaenopsis* sp., *Chroococcus* sp., *Scenedesmus* sp., and diatoms. During spring however, the numbers and kinds of algae increased, the plankton being marked conspicuously by the presence of large numbers of *Ankistrodesmus falcatus, Coelastrum sphaericum,* and *Tetraëdron* sp.

The diel zooplankton community consisted, in the main, of Rotifera and immature Copepoda. The rotifer population dwindled considerably in winter but increased greatly during early summer. A most glaring aspect of the zooplankton was the absence of adult Copepoda and Cladocera. Observations in a near-by pit revealed diurnal vertical migrations by large numbers of *Mesocyclops edax,* a cyclopoid copepod, thus suggesting differences in the composition of zooplankton from day to night.

Total seston contained in the lake at all levels ranged generally from about 5-10 mg/liter. The content of seston in deeper waters rose to nearly 13 mg/liter in July, but decreased significantly in autumn.

Zoobenthic animals retained in a 20 mesh/cm screen were mainly *Chaoborus* sp., a dipteran; the population density reached slightly over 12,000 individuals per square meter in December. This organism becomes planktonic at night. Larvae of another dipteran, *Tendipes* sp., entered the collections during winter, and cyclopoid and calanoid copepods were common to abundant in the benthos throughout the year. Oligochaetes were taken occasionally.

ACKNOWLEDGMENTS

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Dispersion of the Giant African Snail, *Achatina fulica*

D. O. Wolfenbarger

Dispersion of organisms is of specific interest to biologists and of general interest to others. One of the first questions asked concerning the discovery of the giant African snail *Achatina fulica* Bowdich, in Florida in 1969, concerned its dispersal. An account of this is given by Sturgeon (in press). Consideration of dispersion of the snail associated with distance from Africa is given here.

Movement of the giant African snail from its apparent origin into previously uninfested areas has required time. Such movement, or dispersion, had two barriers or hazards in addition to bodies of water; these were time and distance. Energy from within the snail, or from without by means of some agency, was necessary to effect dispersion. Time in greater or lesser amounts, however, is also required for energy to effect dispersion of other species of organisms. Relationships of time and distance were given for dispersion of the tsetse fly, *Glossina morsitans* Wst., by Jackson (1940); of a fruit fly, *Drosophila pseudoobscura* Duda by Dobzhansky and Wright (1943); of *Aedes albopictus* (Skuse) by Bennet and Worcester (1946); of a European corn borer parasite *Lydella stabulans grisescens* R. D. by Baker, et al. (1949) and of three species of flies, *Musca domestica* (L.), *Phaenieia sericata* (Meig) and *Phormia regina* (Meig), by Lindquist et al. (1951). Graphic studies of these data by Wolfenbarger (1959) showed relationships of time and distance in the dispersal of organisms. Much emphasis and considerable data were given by Mead (1961) on dispersal of the giant African snail as it was moved from country to country for over a century in a succession of movements. These data indicated rates of movement of the species from Africa to Hawaii. Consideration of these data and of the infestation in Florida are given here. By whatever means of dispersal utilized by the snail it appeared that a rate of movement could be determined where considerable data were available.

Factors Affecting Dispersion. Information on movement of the snail by man previous to about 1800 is lacking. Much purposeful movement of the giant African snail was made since then by man to islands and countries of the western Pacific and southeastern Asia, especially during the territorial expansion by the Japanese

during the decade 1935-45. Exportations of snails were made for the purposes of raising food for man and as given also by Mead (1961), for barnyard fowls. Purposeful movement was made by man to Hawaii, according to Mead (1961), and to Florida, apparently for aesthetic reasons, as pets or as a novelty. Hitchhiking on or in articles of commerce, is also common with the giant African snail according to records of shipments from countries infested with the pest. Man appears, therefore, to be the primary agent of dispersal in all movements to other islands or distant countries. Bodies of water are barriers to snail dispersal. Crawling is the mode of snail movement on land. Such movement is slow although this phase of snail dispersion also has its rates of dispersal. Can crawling be termed the natural mode and transportation by man the unnatural mode of snail dispersion?

Methods or Procedure. Distances from Africa, in miles, were measured on a globe to the locations given by Mead (1961) and to Florida. Measurements were by means of a tape, made in a more or less direct line from the eastern coast west of Madagascar. The year of recognition of the snail in different countries listed by Mead (1961) and in Florida in 1969, and distances from Africa, were the variables employed in a regression study.

Approximations of distance are accepted in this study firstly because it is impossible to know the point of departure of the snails for a new invasion; secondly the point of arrival cannot be known exactly and thirdly the direction traveled was presumably over water in most instances and cannot be known. Many or most of the snails reported as sources of new infestations, were doubtless several to many generations after those originally from Africa. Furthermore, discovery of the species in newly infested areas may have occurred years after the introduction. Hence, although there are several sources contributing to error, the data give interesting statistical and biological considerations.

Results. Country infested, with year of snail introduction and expected from regression calculations are given in Table 1. Graphical studies of the records in terms of distances as related to the years through construction of a scatter diagram are given in Fig. 1. Plotting the data on uniform spaced grids indicated a curvilinear relationship which was made rectilinear by graphing them on semilogarithmic spacing. Conversion of the distance figures was made

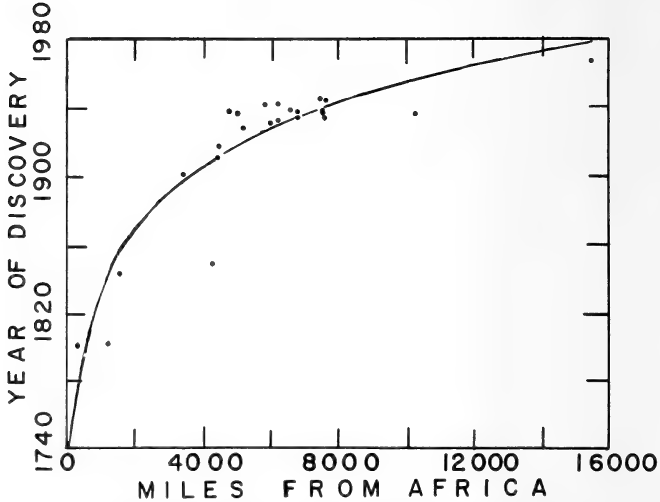

Fig. 1. Regression curve showing relationships of the giant African snail dispersal from the eastern African coast to lands eastward and northeastward years later.

to logarithms, in the manner developed by Wadley and Wolfenbarger (1944), for computation of a regression curve. This curve was drawn in Fig. 1 after reconversion of the logarithms to distance data.

The regression formula determined, following methods given by Snedecor (1956) was

Expected year of infestation = 1441.36 + 128.41 (log X).

The regression coefficient was highly statistically significant, with a t value of 10.6; a highly significant coefficient of correlation was found with $r = 0.91$, and a chi-square test of the data in Table 1 showed a highly nonsignificant value of 7.24, with 23 df and gave further evidence for faith in the curve of Fig. 1.

Conclusions. Regression of the giant African snail on the year recognized in a locality continued from about 1800 to the present in an accumulative manner. Expected year of discovery was 1775

TABLE 1
Observed and calculated year of discovery of African giant snail

Locality	Observed year	Calculated year
Madagascar	1800	1775
Mauritius	1800	1839
Seychelles	1840	1853
Ceylon	1900	1896
India, Calcutta	1847	1908
Singapore	1917	1910
Malaya	1911	1910
Thailand	1937	1914
Vietnam	1937	1916
Sarawak	1928	1919
Hongkong	1941	1925
Amoy	1931	1927
Philippines	1942	1928
Formosa	1932	1928
North Borneo	1939	1932
Caroline Islands	1938	1934
Ryukyu Islands	1935	1934
Palau Islands	1938	1934
New Guinea	1945	1938
Bonin Islands	1938	1939
Mariana Islands	1937	1940
Japan	1933	1940
Bismarck Archipelago	1945	1940
Hawaii	1936	1956
Florida	1969	1979

at Madagascar instead of the observed 1800. Year of snail discovery and distance of the country from Africa were closely related.

Rather uniquely, the giant African snail has dispersed in an easterly direction. Latin American lands of Central and South America and of the Caribbean area apparently remain free of *Achatina fulica*. Low temperatures limit infestations of the temperate zones to areas bordering the torrid zones. Explanations for eastward dispersal appear somewhat conjectural but are suggested. Much of the nearer lands having temperature, moisture, and plants acceptable to the snail, are eastward from Africa. Less industrialization and more dependence on food producing areas near to the human consumers and requiring shorter transportation were doubtless factors favoring eastward dispersion. Greater frequency of man's transportation, and the apparently equal curiosity or aesthetic

desires of peoples in all lands seem unlikely to explain the eastward movements. Japanese expansionary forces mentioned above doubtless aided and abetted untimely snail dispersion to a number of lands according to Mead (1961). Tropical and subtropical lands of the Caribbean, Central and South American countries may become infested with the giant African snail except as it is excluded.

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The Fishes of Lake Okeechobee, Florida

Lothian A. Ager

With the exception of descriptions and ranges of the freshwater fishes of Florida (Carr and Goin, 1959 and Briggs, 1958), fishery surveys of individual bodies of water or watershed areas of peninsular Florida (Bailey, Winn, and Smith, 1954; Hellier, 1967; Hearld and Strickland, 1949; Kilby and Caldwell, 1955; Hubbs and Allen, 1943) have not been sufficient to document accurate range limits of many peninsular Florida species.

This survey of Lake Okeechobee was initiated in an attempt to determine the composition and relative abundance of the fishes since southern range limits of a number of species were poorly documented and since exotic species are flourishing in some peninsular Florida freshwater. Peninsular Florida has a depauperate freshwater fish fauna with such dominant families as Cyprinidae, Catostomidae, and Percidae being represented by 5, 1, and 1 species respectively. On the other hand, the Centrarchidae and Cyprinidontidae are unusually well represented in the freshwaters of peninsular Florida, a result of the uniformly low gradient streams, the past geologic history, and the character of the water (Odum, 1953).

Method of Collection

The survey began in October, 1967, and continued through November, 1969. Collecting was accomplished with trammel nets, seines, a trawl, a 230-volt electrical shocker, and rotenone. Most fish were identified immediately upon collection. Those which could not be identified in the field were preserved in formalin and taken to laboratory facilities for identification with the works of Eddy (1957), Carr and Goin (1959), and Sterba (1966). Rarer specimens were kept while the more common specimens were discarded after identification. Habitat type was noted with the collection of each species.

Results and Discussion

Forty-three species of fish were collected from Lake Okeechobee during the survey. Of these, 36 are freshwater fishes (Table 1), whereas seven are saltwater forms that invade adjacent freshwater

TABLE 1

Freshwater fishes collected from Lake Okeechobee, Florida

Family Amiidae	Family Cyprinodontidae
Amia calva	*Jordanella floridae*
Family Lepisosteidae	*Cyprinodon variegatus*
Lepisosteus platyrhincus	*Luciana goodei*
Lepisosteus osseus	*Fundulus seminolis*
Family Clupeidae	*Fundulus chrysotus*
Dorosoma cepedianum	Family Poeciliidae
Dorosoma petenense	*Poecilia latipinna*
Family Esocidae	*Gambusia affinis*
Esox niger	*Heterandria formosa*
Esox americanus	Family Atherinidae
Family Catostomidae	*Menidia beryllina*
Erimyzon sucetta	*Labidesthes sicculus*
Family Cyprinidae	Family Centrarchidae
Notemigonus crysoleucas	*Micropterus salmoides*
Notropis maculatus	*Pomoxis nigromaculatus*
Opsopoeodus emiliae	*Enneacanthus gloriosus*
Family Ictaluridae	*Chaenobryttus gulosus*
Ictalurus punctatus	*Lepomis marginatus*
Ictalurus catus	*Lepomis punctatus*
Ictalurus natalis	*Lepomis macrochirus*
Ictalurus nebulosus	*Lepomis microlophus*
Noturus gyrinus	Family Percidae
Family Anguillidae	*Etheostoma barratti*
Anguilla rostrata	

areas (Table 2). Although no reproduction of these saltwater species occurs, with the possible exception of the Atlantic needlefish, significant immigration of some saltwater species yields large numbers of their kind, even to the point of their being common. Table 3 lists several species of fishes not found during this study but collected by other investigators (Florida Game and Fresh Water Fish Commission, 1956, Recommended program for northwest shore of Lake Okeechobee, unpublished report).

FAMILY AMIIDAE

1. *Amia calva* Linnaeus. Bowfin. This species is relatively abundant throughout the vegetated areas and the canal systems associated with the lake. Young individuals with the adult male were collected on January 29, suggesting an early spring spawning time.

TABLE 2

Salt water fishes collected from Lake Okeechobee

Family Belonidae
Strongylura marina. Atlantic Needlefish
Family Mugilidae
Mugil cephalus. Striped Mullet
Family Gobiidae
Microgobius gulosus. Clown Goby
Family Soleidae
Irinectes maculatus. Hogchoker
Family Centropomidae
Centropomus undecimalis. Snook
Family Elopidae
Elops saurus. Ladyfish
Megalops atlantica. Tarpon

FAMILY LEPISOSTEIDAE

2. *Lepisosteus platyrhincus* DeKay. Florida Gar. This species was collected from every major habitat within Lake Okeechobee. No individuals less than eight inches total length were collected. Greater numbers of these smaller individuals were collected during April and May as opposed to other months of the year.

3. *Lepisosteus osseus* (Linnaeus). Longnose Gar. Only one individual was collected during the study. It was captured in the open area of the lake.

FAMILY CLUPEIDAE

5. *Dorosoma cepedianum* (LeSueur). Gizzard Shad. This species was plentiful in the open area of the lake and was fre-

TABLE 3

Fishes reported from Lake Okeechobee by other investigators

Family Engraulidae
Anchoa sp. Anchovy
Family Cyprinidae
Notropis chalybaeus. Ironcolor Shiner
Notropis petersoni. Coastal Shiner
Family Aphredoderidae
Aphredoderus sayanus. Pirate Perch
Family Centrarchidae
Elassoma evergladei. Everglades Pigmy Sunfish

quently collected within vegetated areas and canals. Spawning probably occurs from late spring to early fall.

5. *Dorosoma petenense* (Günther). Threadfin Shad. Like the gizzard shad, this species was abundant throughout the open area and frequently collected within the vegetated areas and canals. Spawning evidently takes place during the early fall.

FAMILY ESOCIDAE

6. *Esox niger* LeSueur. Chain Pickerel. This species was not frequently collected within any habitat, but was found on several occasions in association with pondweed, *Potamogeton*. Young individuals were collected during April suggesting that these fish are early spring spawners.

7. *Esox americanus* Gmelin. Redfin Pickerel. This species was relatively abundant within the marginal areas of the lake marsh during April and May, being associated with spikerush, *Eleocharis obtusa*, communities. Few individuals could be found during October and November.

FAMILY CATOSTOMIDAE

8. *Erimyzon sucetta* (Lacépède). Lake Chubsucker. Though abundant, this species occurred most frequently within vegetated areas of the lake where turbidity was extremely low. From the collection of young individuals, spawning must occur in early spring.

FAMILY CYPRINIDAE

9. *Notemigonus crysoleucas* (Mitchill). Golden Shiner. This species was collected from all areas of the littoral zone of the lake as well as from the canal systems. However, the golden shiner seems to prefer areas with a significant cover of water hyacinths, *Eichhornia crassipes*.

10. *Notropis maculatus* (Hay). Taillight Shiner. Through many individuals were collected in association with pondweed and bulrush, *Soirpus validus*, during the early spring, few specimens could be found during the fall.

11. *Opsopoeodus emiliae* Hay. Pugnose Minnow. This species seems to occupy the same areas as the taillight shiner, but is abundant during the fall months when the taillight shiner is scarce.

FAMILY ICTALURIDAE

12. *Ictalurus punctatus* (Rafinesque). Channel Catfish. A much sought after species by commercial fishermen, this species occurs primarily in open water, but during the spring months can be found in abundance within the vegetated littoral zone. Large numbers of 4-5 inch individuals found in the open area during June and July suggest that spawning takes place in the early spring.

13. *Ictalurus catus* (Linnaeus). White Catfish. This catfish is as abundant as the channel catfish and is found in the same areas, but less frequently within the littoral zone. Spawning takes place during the late spring.

14. *Ictalurus natalis* (LeSueur). Yellow Bullhead. This rather scarce species was collected from all areas of the lake but occurred most frequently in the canal systems of the lake.

15. *Ictalurus nebulosus* (LeSueur). Brown Bullhead. A rather abundant species, this catfish was collected within areas of dense vegetation (such as eelgrass, *Vallisneria americana*, and pondweed) where there was an amount of decaying organic material covering the bottom substrate. Young of the year collected as early as Thanksgiving Day suggest that spawning takes place during the winter months.

16. *Noturus gyrinus* (Mitchill). Tadpole Madtom. This scarce catfish was collected primarily from the open area of the lake. This species seems to be more abundant during the fall months.

FAMILY ANGUILLIDAE

17. *Anguilla rostrata* (LeSueur). American Eel. This catadromous species is frequently encountered in the open area of the lake, but at no time is abundant enough to be commercially important. Its numbers do not appear to fluctuate with time of year probably because water control structures on all outlet tributaries restrict migration.

FAMILY CYPRINONDONTIDAE

18. *Jordanella floridae* Goode and Bean. Flagfish. This species is common in shallow water along the marginal areas of the lake and is most abundant during early spring. It can tolerate low dissolved oxygen.

19. *Cyprinodon variegatus* Lacépède. Sheepshead Minnow. This species was collected in small numbers only on two occasions from one area of the lake. Evidently it inhabits the shallow, marginal area of the lake and is closely associated with spikerush communities and clear water.

20. *Lucania goodei* Jordan. Redfin Killifish. This species is one of the abundant minnows found throughout the littoral zone of the lake. Large numbers collected during the fall months indicate that spawning occurs during the summer.

21. *Fundulus seminolis* Girard. Seminole Killifish. The minnow seems to be limited to the littoral zone of the lake, but occurs in a variety of aquatic plant communities. From the numbers collected, it appears to be commonly associated with spikerush communities and areas of water hyacinths.

22. *Fundulus chrysotus* Holbrook. Golden Topminnow. This species was collected quite frequently during April and May within spikerush communities in shallow, clear water, but was seldom encountered during the fall. Perhaps spawning occurs during the early spring.

Family Poeciliidae

23. *Poecilia latipinna* (LeSueur). Sailfin Molly. Small numbers of this species were often collected from canals, but it was more abundant in the very shallow, vegetated portion of the lake marsh. It can evidently tolerate or even thrive in water containing very little dissolved oxygen.

24. *Gambusia affinis* (Baird and Girard). Mosquito Fish. These small fish are abundant throughout the littoral zone and canal systems of the lake in practically all types of marginal waters.

25. *Heterandria formosa* Agassiz. Least Killifish. This tiny species is found throughout the littoral zone and canal areas of the lake. Although never found in large numbers, it is common around all kinds of vegetation growing in or at the edge of the water.

Family Atherinidae

26. *Menidia beryllina* (Cope). Tidewater Silversides. This fish is not frequently collected, but is more abundant during the fall months than during spring. It is associated with communities of pondweed in the littoral zone.

27. *Labidesthes sicculus* (Cope). Brook Silversides. Although found throughout the littoral zone and canals, this species occurs abundantly during the spring in spikerush communities in shallow, clear water. This suggests a spring spawning period.

FAMILY CENTRARCHIDAE

28. *Micropterus salmoides* (Lacépède). Largemouth Bass. This desired game fish is abundant and found throughout the lake and canals. The peak spawning period occurs in February and March. Most adults are found within the littoral zone, occurring most frequently within eelgrass and pondweed communities where turbidities are low. The greatest numbers of immature individuals are found in shallow, clear water within the spikerush communities.

29. *Pomoxis nigromaculatus* (LeSueur). Black Crappie. One of the most abundant and sought after game fish of the lake, this species is primarily pelagic. During January, February, March, and April it can be found throughout the littoral zone of the lake. These months are the spawning season of this species. Young individuals evidently move to the open water immediately after reaching a swim-up fry stage. Sexually immature individuals are rarely found within the littoral zone.

30. *Enneacanthus gloriosus* (Holbrook). Bluespotted Sunfish. This small sunfish can be found within communities of pondweed and eelgrass. Although common, these fish are rarely collected in any significant numbers.

31. *Chaenobryttus gulosus* (Cuvier). Warmouth. This sunfish is found throughout the littoral zone of the lake, most abundantly in association with spikerush communities in shallow, clear water. Seasonal collections indicate that spawning occurs during early spring.

32. *Lepomis marginatus* (Holbrook). Dollar Sunfish. This small member of the sunfish family occurs most frequently in the marginal areas of the littoral zone. It seems to occur more frequently during the spring months than during fall, indicating a spring spawning period.

33. *Lepomis punctatus* (Valenciennes). Spotted Sunfish. This species occurs throughout the littoral zone and canal systems of the lake, but is more frequently collected within the canals. Evidently it can utilize better than other centrarchids the canals and littoral

area with much organic sedimentation. Spawning occurs in late spring prior to that of the bluegill.

34. *Lepomis macrochirus* Rafinesque. Bluegill. Found throughout the entire lake and canal systems, this fish is probably the most numerous of centrarchids. Adults are most frequently collected within communities of bulrush, while great numbers of immature individuals are found within dense pondweed and eelgrass communities. Spawning occurs throughout the summer months.

35. *Lepomis microlophus* (Günther). Redear Sunfish. A much desired game fish, this species occurs throughout the lake and canal systems. Adults are found primarily within bulrush communities from late spring to early fall. During the remainder of the year, it seems to prefer the deeper, pelagic area of the lake. Immature individuals are most frequently found within dense communities of pondweed and eelgrass, but occur in eelgrass more frequently than immature bluegills, which are dominant in pondweed. From collections it seems these fish can better utilize the marginal areas of the littoral zone than can the bluegill.

Family Percidae

36. *Etheostoma barratti* (Holbrook). Scalyhead Darter. A rather common but seldom collected species because of its bottom dwelling habits and small size, it is most abundant within the marginal areas of the lake and the canals.

Family Belonidae

37. *Strongylura marina* (Walbaum). Atlantic Needlefish. This species is commonly encountered throughout the open area of the lake and within the bulrush communities. A number of gravid females and ripe males have been collected during spring. Individuals of 1-2 inches in total length were frequently collected during summer months, indicating that reproduction occurs within the lake so that this population is not dependent upon their ability to immigrate into the lake.

Family Mugilidae

38. *Mugil cephalus* Linnaeus. Striped Mullet. This common salt water species is abundant throughout the open area and most

of the littoral zone from early winter to summer. Spawning does not occur in the lake. During late spring, great numbers can be found in the tributaries leading from the lake to the ocean. Likewise, during late fall this fish can be found migrating into the lake by way of these same tributaries.

FAMILY GOBIIDAE

39. *Microgobius gulosus* (Girard). Clown Goby. This fish was collected on two different occasions from a community of white water lily (*Nymphea odorata*) and bladderwort (*Utricularia vulgaris*). It was much more abundant during the fall than during spring, an indication that spawning occurs during the summer months.

FAMILY SOLEIDAE

40. *Trinectes maculatus* (Lacépède). Hogchoker. Only one individual was found during the survey. It was captured with a seine in the open portion of the lake.

FAMILY CENTROPOMIDAE

41. *Centropomus undecimalis* (Bloch). Snook. This species was frequently collected in the Clewiston area where navigation channels have been dredged into the lake. The population is evidently entirely dependent upon its ability to immigrate into the lake.

FAMILY ELOPIDAE

42. *Elops saurus* Linnaeus. Ladyfish. On one occasion a school of these fish were sighted in the pelagic area of the lake east of the Caloosahatchee Canal.

43. *Megalops atlantica* Valencinnes. Tarpon. On one occasion in August a tarpon was seen cruising the surface near Rita Island in the southern portion of the lake.

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A Yellowfin Menhaden Without Pelvic Fins

William F. Hettler, Jr.

Menhaden occasionally have one or both pelvic fins missing. This is usually attributed to attacks by predators. Reports of deformed menhaden are limited to pugheadedness and vertebral anomalies (Dahlberg, 1970a; Lewis, 1966; Musick and Hoff, 1968; Schwartz, 1964-65; Sutherland, 1963; and Warlen, 1969). Gunter and Ward (1961) reported a Gulf menhaden, *Brevoortia patronus*, with its pelvic girdle and fins bitten off. Marr (1945), noting missing pelvic fins in a northern anchovy, *Engraulis mordax*, urged that anomalies of possible evolutionary significance should be reported.

A yellowfin menhaden, *B. smithi*, lacking pelvic fins was taken by gill net in the Indian River, near Sebastian, Florida, on January 23, 1965. The fish, a 212 mm (standard length), 2-year-old female, was normal in all other external characteristics (Fig. 1). Apparently the pelvic fins and the axillary appendages (elongated scales around the insertion of the fin) never developed.

An x-ray photograph showed a pelvic girdle between the dorsolateral projections of scutes 16 and 22. The girdle was dissected and found to be deformed (Fig. 2). Both pelvic bones were fused together. The anterior end of the left pelvic bone appeared normal, but the right bone apparently turned upside down and grew downward into the "V" of the keel. The small actinosts that normally support the rays of each pelvic fin were not found; girdle musculature was reduced. In normal menhaden, the two dorsolateral projections of the scute at the posterior end of the girdle are either notched near the base, or missing, where the pelvic fin passes through the keel. None of the scute projections near the pelvic girdle in this fish were notched or missing. Figure 3 illustrates a normal pelvic girdle with fins attached.

The anomaly may be related to hybridization of menhaden in the Indian River. Dahlberg (1970b) concluded that yellowfin menhaden hybridize with Atlantic menhaden, *B. tyrannus*, on the east coast of Florida. The specimen reported here, however, was not a hybrid. There may be evolutionary significance in the loss of pelvic fins in yellowfin menhaden. Several other clupeid fishes, in the subfamily Pristigasterinae, lack pelvic fins. Hildebrand (1963) stated

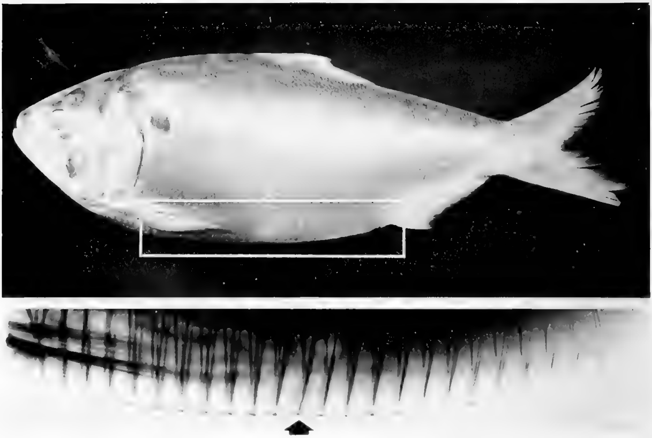

Fig. 1. A 212-mm yellowfin menhaden lacking pelvic fins; radiograph of same fish showing position of deformed pelvic bone, above 20th abdominal scute (arrow). Scutes 9 through 32 are visible in the x-ray.

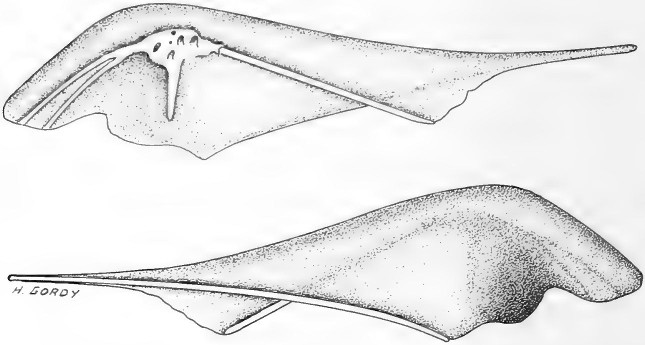

Fig. 2. Deformed pelvic girdle; the right (top) and left (bottom) pelvic bones fused together. The girdle is 22 mm. long.

that yellowfin menhaden do not school as do the commercially important Atlantic menhaden; neither do they migrate long distances. The presence or absence of pelvic fins may be unimportant to non-

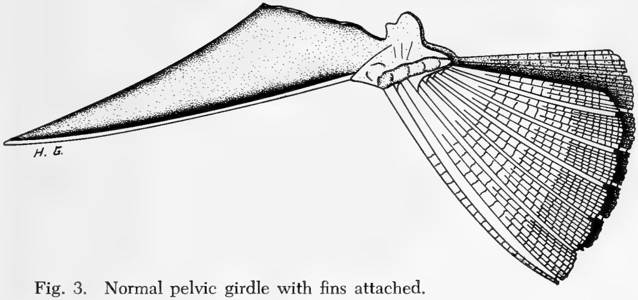

Fig. 3. Normal pelvic girdle with fins attached.

schooling, nonmigratory yellowfin menhaden. It is difficult to conclude much about the significance of this observation without knowing how many menhaden lack pelvic fins. During previous trips to the Indian River to collect ripe gametes from yellowfin menhaden, I incidentally noted a small percentage of this species with missing or atrophied pelvic fins. Unfortunately, I kept no records of the incidence. I suggest that biologists not inclined to do so, keep accurate records and report the frequency of occurrence of deviations from normal conditions, such as the anomaly I have reported.

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The Shrimp *Leptalpheus forceps* in Old Tampa Bay, Florida

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The alpheid shrimp, *Leptalpheus forceps* Williams, was collected in Old Tampa Bay, Florida, during studies of benthic invertebrates. This marked the first collection of the species outside the type locality, Beaufort, North Carolina. It was reported there by Williams (1965) as a commensal in burrows of the macruran crustacean, *Upogebia affinis*. The purpose of this report is to document occurrence of the shrimp in Old Tampa Bay, describe the collection site, and record certain ecological conditions in the habitat. These features include sediment type and hydrology within the burrows and from surrounding water. Abundance, size, and reproductive state are also recorded.

Collection Site

Specimens of *Leptalpheus forceps* were collected from exposed intertidal burrows of *Upogebia affinis* in the northeastern section of Old Tampa Bay adjacent to the town of Oldsmar (Fig. 1). In that area of the bay there is a broad, unvegetated, sandy beach at low tide, and large numbers of *U. affinis* occur in a narrow zone near the level of mean low water. A hole in the sediment marks the burrow of the animal (Fig. 2).

The shore adjoining the beach is undeveloped except for a fishing pier extending into the bay about 50 m south of the collection site. Small oyster bars are present on the tidal flats, and cord grass, *Spartina* sp., grows along the edge of the bay.

Procedure

References to trade names in this publication do not imply endorsement of commercial products.

Bottom material containing burrows of *Upogebia affinis* was dug with a shovel and washed on a fine sieve (Tyler, #24 screen, 0.701 mm mesh). The material was removed to a depth of 1/2 m and within an area of 1/9 m^2 marked by a wooden frame. The frame was placed randomly in areas having a large number of burrow

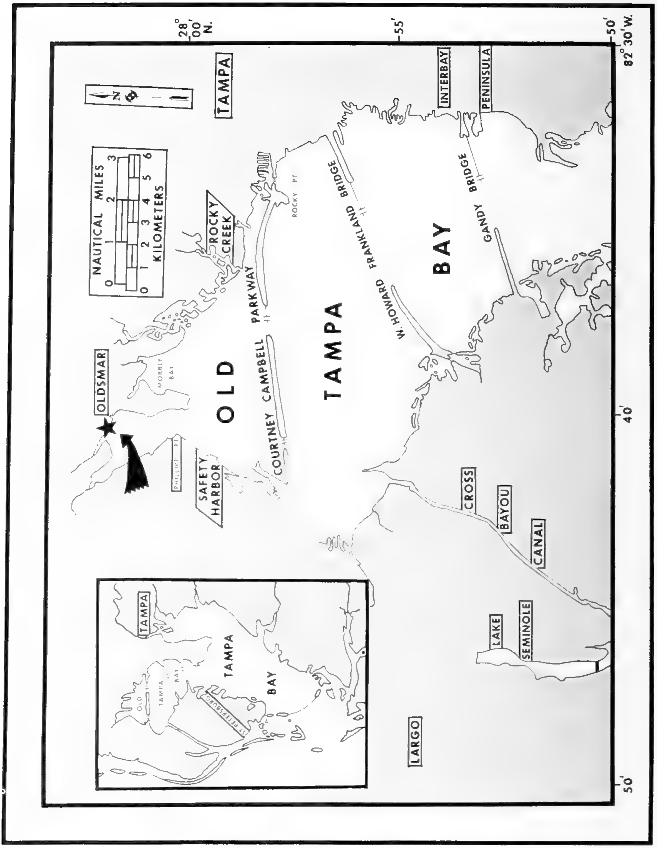

Fig. 1. Collection site (star) for *L. forceps* in Old Tampa Bay, Florida, 1967-1968.

openings. *L. forceps* and its host were picked off the sieve and fixed in 10 per cent sea-water formalin. For permanent preservation, specimens were stored in 70 per cent isopropanol.

Sediment was sampled within each quadrate with a corer (Tay-

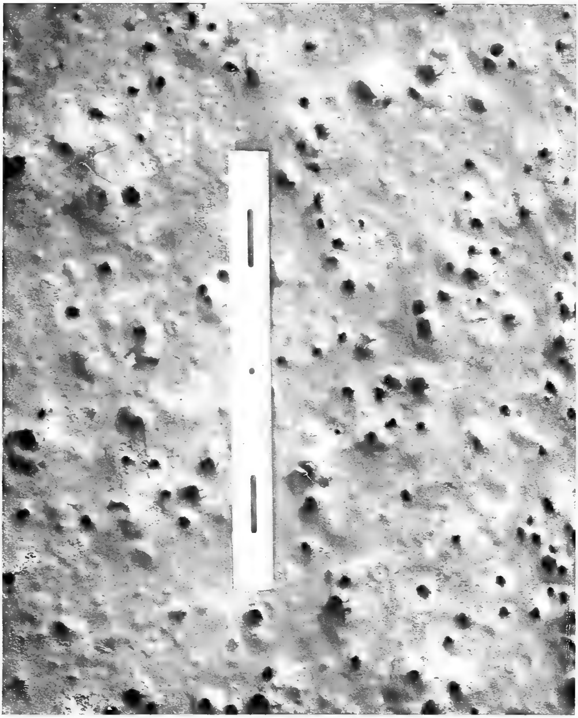

Fig. 2. Burrow openings of *U. affinis* on the beach near Oldsmar, Florida, in upper Old Tampa Bay, 1967-1968. Ruler is one foot long.

lor, 1965). The sediment core was sectioned at 5-cm intervals from the surface to a depth of about 25 cm. No obvious stratification of particle sizes was observed in the sediment cores. Analysis for total sediment texture was made according to methods described by Taylor and Saloman (1969).

Water was sampled concurrently in exposed burrows and in the bay nearby. Water from burrows was removed by mouth suction through a polyethylene tube fitted with a tapered glass tip for insertion in burrow openings. Hydrological factors compared between water from burrows and the bay included temperature, salinity, *p*H, total Kjeldahl nitrogen, total phosphorus, and dissolved oxygen. In addition to these features, analysis of bay water also included turbidity. Average hydrological conditions for upper Old Tampa Bay and methods of water analysis were reported by Saloman, Finucane, and Kelly (1964); Saloman and Taylor (1968); and Saloman and Taylor (in press).

Observations on the biology of *L. forceps* included abundance, carapace length, reproductive state, and number of eggs per female. Carapace length was determined with an ocular micrometer by measuring from the posterodorsal margin to the anterodorsal margin that covers the eye. Reproductive stages were noted, and eggs on each gravid female were removed from the abdomen and counted.

SEDIMENT

Burrows of *Upogebia affinis* were dug in sediment that had an average composition of 95.3 per cent silicious sand, 1.3 per cent silt, and 3.4 per cent clay. Only a small fraction of the sand size sediment particles consisted of carbonate material. Other analyses from upper Old Tampa Bay north of Phillippi Point showed that the average weight percentage of silicious sand, silt, and clay was 91, 5, and 4, respectively (Taylor and Saloman, 1969). Statistical data from these studies show that sediment sorting is poor (1.319 $\emptyset$) and indicate that there is little uniformity in the particle size of the sand fraction (Folk, 1964).

HYDROLOGICAL CONDITIONS

Average hydrological conditions recorded near the collection

TABLE 1

Hydrographic observations for 1967-1968 from the collection site for *L. forceps* in Old Tampa Bay, Florida*

Month	Year	Water temp. C	Salinity ppt	*pH*	Total phosphorus μg at./l	Total Kjedahl nitrogen μg at./l	Dissolved oxygen ml/l	Jackson Turbidity units
January	1967	22.0	24.11	8.01	24.8	50.7	4.83	6.0
	1968	20.7	25.44	7.63	26.2	53.6	4.59	19.5
February	1967	16.5	24.83	8.08	29.9	33.3	4.83	1.4
	1968	18.1	27.05	7.92	9.2	2.1	3.70	2.3
March	1967	16.2	24.96	8.04	18.0	57.3	4.91	4.9
	1968	14.7	28.39	8.13	22.9	5.7	4.91	1.7
April	1967	22.4	26.64	7.79	23.6	49.3	4.43	12.0
	1968	23.7	29.22	8.11	30.3	40.0	4.11	2.2
May	1967	22.8	28.35	7.95	23.3	68.0	4.27	5.9
	1968	22.8	30.34	7.81	29.5	47.1	3.54	9.3
June	1967	29.1	29.43	7.83	23.2	53.4	3.06	5.5
	1968	26.5	30.46	7.79	24.1	54.3	2.58	6.0

*Data on file at the Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida 33706.

TABLE 1 (Cont.)

Hydrographic observations for 1967-1968 from the collection site for *L. forceps* in Old Tampa Bay, Florida*

Month	Year	Water temp. C	Salinity ppt	pH	Total phosphorus μg at./l	Total Kjedahl nitrogen μg at./l	Dissolved oxygen ml/l	Jackson Turbidity units
July	1967	29.5	29.61	7.80	21.0	54.3	2.98	3.5
	1968	28.8	27.05	7.76	16.4	62.8	2.58	3.0
August	1967	28.6	27.66	7.67	25.2	42.3	2.58	4.9
	1968	31.0	23.93	7.98	26.8	67.8	1.46	8.7
September	1967	27.9	22.90	7.48	27.8	50.8	2.50	8.9
	1968	28.5	20.95	7.70	30.7	42.8	2.10	4.5
October	1967	24.4	24.07	7.99	28.4	28.6	3.87	21.0
	1968	25.7	20.14	7.73	31.6	46.4	1.70	7.5
November	1967	24.0	24.07	7.75	26.1	54.3	3.87	53.0
	1968	22.7	20.10	7.78	—	71.4	3.14	29.0
December	1967	17.2	25.44	7.78	26.8	35.7	3.78	5.2
	1968	22.6	20.37	7.88	29.1	25.7	4.67	27.0
Average	1967	23.4	26.01	7.85	24.5	48.2	3.83	11.0
	1968	23.8	25.29	7.85	25.2	43.3	3.26	10.1
Average		23.6	25.65	7.85	24.8	45.7	3.54	10.5

*Data on file at the Bureau of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida 33706.

TABLE 2

Hydrographic data from burrows of *U. affinis* and the commensal shrimp *L. forceps* in Old Tampa Bay, Florida, 1967-1968

Date	Temp. C	Salinity ppt	*p*H	Total Kjeldahl nitrogen μg at./l	Total phosphorus μg at./l	Dissolved oxygen Ml/l
1967						
10-28	24.2	23.73	7.49	33.6	31.1	
11-3	25.6	23.19	7.30	117.1	35.2	0.65
						0.06
11-19	20.0	25.48	7.42	30.7	26.1	1.10
		25.26				1.21
12-23	20.0	26.15	7.20	42.8	30.7	0.36
		25.81	7.14	14.3	25.1	0.32
12-31	15.7		7.79	98.6	25.1	
1968						
1-16*	15.0	26.29	7.52	72.1		3.78
						2.60
†	15.5	26.65	7.42	62.1	30.4	1.42
						0.84
1-28	17.5	27.12	7.40	95.0	26.1	2.36
		27.12	7.44	110.7	28.3	0.84
2-17	17.0	27.30	7.66	124.3	31.4	
		27.39	7.77	121.4	24.0	
3-2	12.0	28.31	7.79	123.6	28.9	
		28.55	7.79	53.6	26.2	
3-16	18.8	27.63	7.67	104.3	34.2	
		28.24	7.88	37.8	34.2	
3-28	19.8					
4-13	22.7	29.60	7.51	160.0	32.4	
Average	18.8	26.70	7.54	82.5	29.3	1.29

*0930 sampling time
†1100 sampling time

site show that upper Old Tampa Bay north of Phillippi Point is a moderately turbid and nutrient-rich body of warm, brackish water (Table 1). Heavy concentrations of total phosphorus and total Kjeldahl nitrogen are mainly a result of domestic sewage which enters Old Tampa Bay north of Courtney Campbell Parkway. The sewage originates from eight treatment plants which have a combined design capacity of 1.2 million gallons per day (unpublished data, Gulf of mexico Estuarine Inventory Project, on file at Bureau

TABLE 3

Hydrographic data from surface water collected concurrently with hydrographic data from burrows of *U. affinis* and *L. forceps* in Old Tampa Bay, Florida, 1967-1968

Date	Temp. C	Salinity ppt	*p*H	Total Kjeldahl nitrogen μg at./l	Total phosphorus μg at./l	Dissolved oxygen Ml/l
1967						
10-28	22.7	24.52	7.92	51.4	29.0	
11-3	23.5	23.13	7.53	85.7	27.1	3.62
						3.70
11-19	21.2	24.90	8.05	21.4	25.3	3.35
12-23	21.2	25.26	7.93	61.4	25.1	5.31
						4.36
12-31	14.9	16.63	8.00	60.7	25.1	
1968						
1-16*	13.2	26.46	7.71	42.8	27.1	4.95
						5.19
†	14.5	26.33	8.20	45.7		5.54
1-28						6.25
	19.3	27.12	8.11	44.3	28.3	6.36
2-17						6.48
	15.8	27.48	7.83	45.7	29.1	
3-2						
	12.2	28.21	7.84	17.8	23.6	
3-16						
	20.2	28.78	7.83	44.3	30.3	
3-28		30.77				
4-13	20.8	29.45	7.65	43.6	28.9	
	23.7	26.81	7.87	40.7	26.8	
			7.96	42.1	28.6	
Average	18.7		7.90	46.8	27.0	4.88

*0930 sampling time
†1100 sampling time

of Commercial Fisheries Biological Laboratory, St. Petersburg Beach, Florida 33706). Water circulation in the bay is poor, and nutrients introduced by sewage and land drainage are mostly retained in a cycle of organic production and decomposition as outlined for similar estuarine systems by Duke and Rice (1967). As an annual average, gross primary production by phytoplankton in Old Tampa Bay is 1.23 and 1.22 kcal/m^2/day for 1965 and 1966, respectively (Saloman and Taylor, 1968).

Comparison of water in exposed burrows of *U. affinis* and nearby surface water showed marked differences in *p*H, total Kjeldahl nitrogen, total phosphorus, and dissolved oxygen (Tables 2 and 3). These differences show that biological processes of occupants in the burrow cause an appreciable change in water chemistry during low tide. The two factors that fluctuated mostly were total Kjeldahl nitrogen and dissolved oxygen. In comparison to surface water in the bay, the water in burrows increased in total Kjeldahl nitrogen and decreased in dissolved oxygen by an average of 35.7 μg at./1 and 3.59 ml/1, respectively (Tables 2 and 3).

The degree to which *U. affinis* and *L. forceps* are adapted to these changes apparently sets limits on the shoreward location of burrows. At Oldsmar, most burrows are near the level of mean low tide where they are exposed for no more than a few hours at each ebb tide. Some are at higher levels on the beach, however, and burrows also occur offshore to an undetermined distance.

ABUNDANCE

The greatest number of *L. forceps* collected from a single sample of 1/9 ^{2} was 6. This sample also contained 13 specimens of *U. affinis* and 32 burrow holes. From 7 samples of 1/9 m^2, the mean number of *L. forceps* was 3.3 and the average numbers of *U. affinis* and burrow holes were 20 and 37.9, respectively (Table 4).

TABLE 4

Number of *L. forceps* relative to numbers of *U. affinis,* and burrow holes in samples from an area 1/9 m^2 by 1/2 m deep

Number burrow holes of *U. affinis*	Number *U. affinis*	Number *L. forceps*
18	4	1
25	9	2
31	17	2
32	13	6
50	26	2
50	48	5
59	23	5
—	—	—
Average 37.9	20.0	3.3

TABLE 5

Carapace length, reproductive state, and number of eggs per female for specimens of *L. forceps* from Old Tampa Bay, Florida, 1967-1968

Date	No. of specimens	Carapace length mm	Reproductive state Nongravid	Gravid Noneyed	Gravid Eyed	No. of eggs
1967						
9-10	2	3.8-5.3		1	1	70-89
10-8	1	4.1	1			
10-21	2	3.6-5.0	1		1	73
11-19	2	4.3-4.8	2			
12-16	1	5.2	1			
12-31	2	3.9-6.0	2			
1968						
1-16	5	4.9-6.7	5			
2-17	3	6.0-6.2	3			
3-2	5	3.9-5.3	5			
3-16	9	3.8-6.6	9			
3-28	6	4.2-7.6	6			
4-13	1	6.3			1	103
4-27	3	5.7-7.1	1	1	1	140
5-11	3	3.4-6.6	2		1	48
5-25	3	5.3-6.9	2	1		107
6-15	3	6.4-6.9		2	1	226-258
7-12	3	6.4-6.7		1	2	116-178

CARAPACE LENGTH AND REPRODUCTIVE BIOLOGY

Carapace length ranged from 3.4-7.6 mm. The larger figure is nearly equal to that recorded for the holotype (female) described by Williams (1965). Specimens were collected in 11 consecutive months, but probably for several reasons no definite pattern of growth was observed (Table 5). The small number of individuals collected per month made growth calculations by mean size or size frequency distribution difficult. *L. forceps* has an extended spawning period (April-October), and this allows juveniles to enter burrows in all seasons except winter. Furthermore, the sampling failed to yield any postlarval or early juvenile individuals. The smallest shrimp had a carapace length of 3.4 mm, which is only 0.4 mm less than the length of one individual that was gravid (Table 5).

Gravid females had a carapace length ranging from 3.8-7.1 mm. Numbers of eggs increased with size of females, and the number

per individual ranged from 48-258 (Table 5). Counts were approximate because some eggs were lost in handling. More eggs per individual were found on specimens collected in June than in any other month. Eggs in the eyed condition were observed on animals collected in September, October, April, May, June, and July. As noted by Manning (*in* Williams, 1965) the living eggs of *L. forceps* were transparent, but became green when preserved in formalin.

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Determination of the Onset of Yolk Deposition in Lizards

Sam R. Telford, Jr.

Population studies of various lizard species have described the female reproductive cycle either from examination of ovaries in preserved specimens (Tinkle, 1961; Mayhew, 1963, 1965, 1966a, 1966b; Telford, 1969) or by observation of living females in the field (Blair, 1960; Harris, 1964). The former method is most precise and furnishes detailed data on all aspects of the ovarian cycle. However, it necessitates removal of individuals from the study population, or extrapolation from data obtained by sampling adjacent populations. No techniques have yet been devised which permit workers to determine the timing of early events in the ovarian cycle from living lizards in the field.

During my studies on the parasitology of various lizard populations in California, Japan, and Panama, blood smears were routinely made from all specimens captured, by clipping toes prior to killing the lizards for autopsies. I noticed upon many occasions that a peculiar staining reaction occurred on some of the slides, a reaction immediately obvious without the use of a microscope. Giemsa-stained thin blood smears characteristically appear bluish-gray to the naked eye. In those which attracted my attention as presenting an odd staining reaction, the smears appeared reddish, a deep pink to brick-red. Upon microscopic examination, a reddish precipitate was found adhering to the glass in the spaces between blood cells. Blood cells stained fairly normally, but the reddish precipitate often obscured an otherwise acceptable stain.

Upon checking the sex of specimens which produced reddish stains, all were found to be female. This immediately suggested a correlation with reproductive condition. A series of 141 slides made from the Japanese lacertid *Takydromus tachydromoides* during its reproductive season, April-May 1967, were examined, and condition of the stain noted. Forty-one presented the abnormal, reddish stain, and 100 appeared bluish-gray. All 41 with red stains were female.

Examination of ovaries from the 41 females revealed that yolked follicles ranging in size from 1.8-7.6 mm diameter were present in 37, three had oviductal eggs without yolked follicles, and five con-

tained both yolked follicles and oviductal eggs. Five of the 100 lizards with normal blood smears were females, all between 39 and 45 mm snout-vent length (SV). Only one of these contained yolked follicles, a female 43 mm SV, and the follicles were small, 1.6-1.9 mm diameter. The remaining 95 lizards were adult and juvenile males.

Adult female *Takydromus tachydromoides* emerge from hibernation in the last week of March or first week of April with small yolked follicles (Telford, 1969). Vitellinogenesis for clutch one increases sharply in rate during the latter half of April (Telford, 1970). Clutch one is deposited in May, clutch two in June, and clutch three in early July. Hatchling females of the previous fall reach maturity at 41-45 mm SV, usually in May (Telford, 1969) or early June. Their first clutch is deposited in early June and their second or third, depending upon when they reach maturity, in late July.

Slides with reddish precipitates were not obtained from females prior to mid-April or from August to hibernation in late October. It is a reasonable conclusion that this reddish precipitate results from lipid materials mobilized during vitellinogenesis, and that its appearance in a lizard population heralds the onset of vitellinogenesis of the ovarian follicles in sexually mature females.

This method may prove to be of general use with all groups of lizards. Twenty-five species of eight families in which I have observed this correlation between reddish stains and active female reproduction include the following: Gekkonidae, *Lepidodactylus lugubris, Thecadactylus rapicaudus, Gehyra mutilata, Hemidactylus frenatus*; Sphaerodactylidae, *Gonatodes albogularis fuscus;* Xantusiidae, *Lepidophyma flavimaculatum*; Iguanidae, *Uta stansburiana, Sceloporus graciosus, Anolis biporcatus, A. limifrons, A. tropidogaster, A. frenatus, A. auratus, A. lionotus, A. poecilopus, Polychrus gutturosus, Corytophanes cristatus;* Teiidae, *Ameiva ameiva, Gymnopthalmus speciosus*; *Leposoma rugiceps*; Lacertidae, *Takydromus smaragdinus*; Agamidae, *Japalura polygonota*; Scincidae, *Eumeces laticeps, Lygosoma pellopleurum, Mabuya mabouya.* The reddish stain has been noted more casually in many other species than those mentioned. Final evaluation of the technique, however, awaits its use in a specific field study designed to test its significance.

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Introduction to the Chemistry of the High Atmosphere

J. A. Llewellyn

It is possible, on the darkest night, far away from cities and other man-made light sources, to detect a light in the sky which is not from the stars. This faint air-glow which has intensity comparable with a candle 300 feet away, is one sign we have of the response of the earth's atmosphere to the harsh fluxes of radiation from the sun. In this case, the sign is an indirect one, arising for the most part from chemical reactions between the tattered remains of the basic atmospheric constituents. In the following, a selective survey is given of the explanations provided by physico-chemical analysis of some of the observations.

Until recently, almost the only source of observations was the optical telescope. A telescope fitted with a spectrograph is capable of observing a wide variety of luminescent phenomena, limited in range by the absorbing qualities of the lower atmosphere. Use of multiple ground bases and triangulation can lead to moderately accurate estimates of the altitudes at which various luminescent processes occur. The telescope observations are now supplemented by observations made from balloons and rockets carrying a variety of instruments including photometers, optical and mass spectrometers, as well as sampling devices using cryogenic surfaces to trap representative specimens of the atmosphere. A relatively coherent picture of the structure of the atmosphere has emerged, and although many of the details are still obscure, we are now in a position to attempt to explain some of the broad features of the upper atmosphere (Massey and Potter, 1961; Donahue, 1968).

We know that the energy of ultra-violet and x-radiation from the sun, radiation of wavelength less than 1027A, principally ends up as ionization. Some of these electrons freed from the molecules of the

upper atmosphere, have sufficient energy to produce more ionization before their energies are dissipated but they end up as an electron gas, until they encounter oppositely charged ions and can recombine. The solar radiation longer than 1100A is dissipated in a variety of ways but notably in the dissociation of molecular O_2 to atomic O at altitudes above about 90 km. The extent of dissociation of oxygen depends on altitude. At 100 km the turbulent mixing of the atmosphere has almost stopped and the diffusive separa-

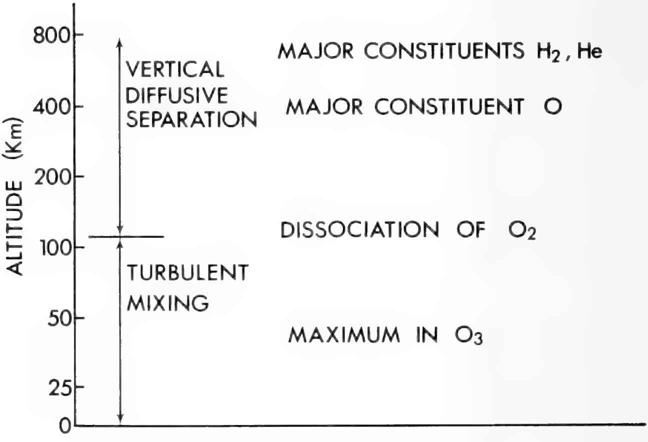

Fig. 1. Constitution and behavior of the atmosphere.

tion of the lighter atoms from the heavier molecules has started. By 120 km the atomic O population exceeds that of the molecular O_2 and by 200 km the O concentration exceeds that of N_2. Above this again the atmosphere above 1000 km is mostly H and He atoms. Figs. 1-2 show the broad outlines of the atmospheric variations.

Having obtained some idea of the contents of the atmosphere, we now consider the following range of processes which are undoubtedly occurring: (1) photon and electron impact ionization; (2) recombination; (3) excitation, again both by photon and elec-

tron collision; (4) radiation from excited atoms produced in (3); (5) chemical reactions between the various ions, excited species and molecular fragments.

In order to produce an atmospheric theory we need to know not only the abundances of the various constituents but also the radiation fluxes which produce them and the rates of the chemical reactions which also govern their relative concentrations. The attack has been made both in the field and in the laboratory. The solar radiation spectrum has been carefully measured by rocket borne spectrometers and spectrographs by a number of national laboratories and is relatively well established (Hintereggir, 1965;

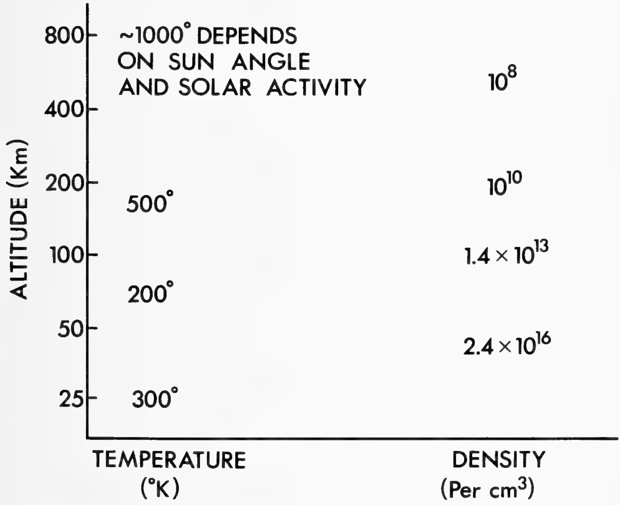

Fig. 2. Temperatures and particle densities.

Tousey, 1964). In the laboratory, systematic investigations of production efficiencies and reaction rates have been made (Ferguson, 1967). Two examples of the laboratory approach may be considered.

THE FLOWING AFTERGLOW METHOD

This method has probably been the most successful approach to measurement of reaction rates for the extremely reactive species which are found in the upper atmosphere (Cermak et al., 1968). Ions are produced in a variety of ways in an electrical discharge afterglow and are carried in a buffer (nonreacting) gas such as He or Ar down a tube past a position where the reagent is added. The gas composition is then sampled by a quadrupole mass spectrometer at the end of the tube. The ion disappearance as a function of added reactant leads directly to a rate measurement. As an example, one may add O_2 in fairly large quantity to He immediately after the discharge and convert He^+ ions to O^+ and He metastable excited species to O_2^+ by reaction. One then has a source of O^+ and O_2^+ ions buffered in He for further reaction studies, e.g. by adding a second reactant, say N atoms at a point further down stream. Both positive and negative ions can be obtained in this apparatus and some of the problems associated with defining the states of the reagents are avoided.

THE ELECTRON BEAM METHOD

This method has been under development for some time and shows promise of versatility for a wide range of reaction measurements. In its simplest form, an electron beam is projected into the gas under observation and the resulting luminescence is observed through an appropriate window by a spectrometer. Observations can be made from infra-red to vacuum ultra-violet. At low pressures, by observing the photon intensity resulting from a given electron beam intensity one can obtain efficiencies for the production of a variety of excited states of both neutral and ionic species as a function of the energy of the electron in the beam. When the pressure is allowed to increase, secondary effects can come into action and luminescent reactions caused by the collision of excited molecules (produced by electron impact) with other gas molecules can also be observed. By the use of an optical scanning system, the luminescent intensity around the exciting beam can be measured and the data interpreted in terms of the rates of the various secondary reaction processes.

With the data provided by laboratory observations (Donahue, 1966) and the solar flux intensity measurements, we can calculate

the rate of ion production for any specified sun direction. As the ultra-violet radiation penetrates the atmosphere the ionization rate increases at first, because increasing atmospheric density provides more targets. The rate reaches a maximum as the radiation is absorbed and then declines. We can compare these calculated rates with the ionization densities in the atmosphere, determined by rocket flights and radiowave reflection experiments and it is immediately obvious that there is little resemblance between calculated altitude profiles of production rates and observed abundances. The N_2^+ ion is produced in greater abundance than any other species and yet is a relatively minor constituent; conversely, the NO^+ ion is a major species although NO itself is a minor atmospheric constituent. A further anomaly is provided by the observation that the O^+ ion density and the electron density reach a maximum some 100 km above the region of greatest O^+ production. Clearly some complicating factors are intervening and we must consider the possible life-styles and deaths for ions after their creation. Ultimately, recombination awaits all ionic species and there are alternative ways to go. (a) Radiative recombination. In this process,

$$A^+ + e \rightarrow A + \text{photon}$$

the system radiates as the electron is captured. It is a relatively inefficient process but may be the only significant route for atomic ions at low pressures. (b) Dissociative recombination. In this process,

$$AB^+ + e \rightarrow A + B + \text{kinetic energy}$$

the energy release associated with electron capture by the ion is dissipated by breaking the bond in the molecule and in accelerating the fragments produced by this bond rupture. This process can be highly efficient and for diatomic ions like N_2^+, NO^+, O_2^+ is about 10^5 faster than the radiative recombination of O^+.

We can see qualitatively, that at low altitudes where the ions which are produced are mostly diatomic, that the charged particle density is expected to be lower than at the higher levels there the ions are mostly atomic with their slower recombination rate. A fresh point emerges however because from information about the

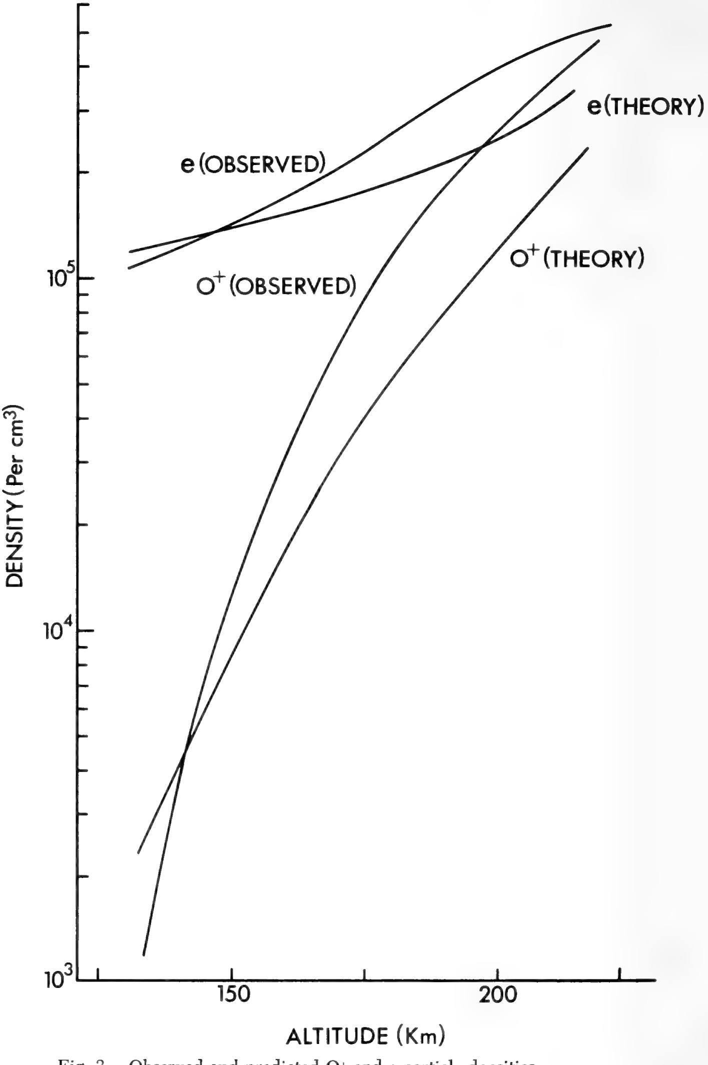

Fig. 3. Observed and predicted O^+ and e particle densities.

production rate and the observed ion abundance we can calculate what the recombination rate must be. When this is done, we find that the rate at which O^+ recombines in the atmosphere is too high for it to be the result of radiative recombination. Some time ago this anomaly was unraveled by postulating the following processes (subsequently confirmed in the laboratory):

(c) $O^+ + O_2 \rightarrow O + O_2$
charge exchange

(d) $O^+ + N_2 \rightarrow N + NO^+$
ion atom exchange

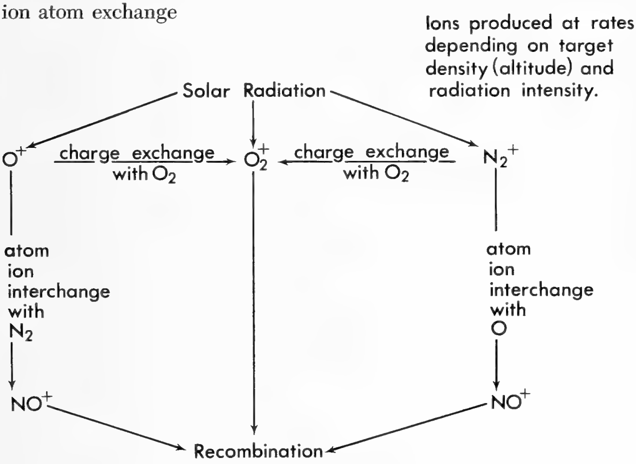

Fig. 4. Process of balance between positive ion density and negative ion density.

In these processes the atomic ions are converted to diatomic ions which may subsequently undergo dissociative recombination. They may also participate in other ionic reactions such as

(e) $N_2^+ + O_2 \rightarrow O_2 + N_2^+$

(f) $N_2^+O \rightarrow N + NO^+$

which help to explain the lowered abundance of N_2^+ and the high levels of NO^+ observed in the atmosphere.

These fundamental notions have been applied to analysis of specific regions in the atmosphere. In this analysis the following scheme is applied:

(1) It is assumed that the reaction rates are so fast that they can keep pace with changes produced by diffusion and changing sun angle so that a steady state results.

(2) The rates of production of ions must balance the loss rates via recombination, and for a specific ion the production rate must balance the loss rates which arise not only from recombination but also from transformation to other ions by reactions such as c, d, e, f.

TABLE 1

Emitters in visual airglow

Wave Length	Emitter
3914	$N_2\ (A) \rightarrow N_2\ X$
5200	$N_2\ D$
5577 oxygen green line	$O\ (^1S) \rightarrow O\ (^1D)$
5893	Na
6300	$O\ (^1D) \rightarrow O\ (^3P)$

(3) The positive ion density must balance the negative ion density. Fig. 4 illustrates the process and the most important reactions.

The results of such analyses are qualitatively correct as can be seen from Fig. 3. Currently the problems seem to hinge on the validity of theoretical estimates of the rates of O^+ production. It appears however that this relatively simple model is capable of being modified to account for many of the complex phenomena observed in the E and F_1 regions of the ionosphere.

We now pass from the technologically important ionosphere to a consideration of the airglow referred to in the opening sentences. The glow is distinct from that of the brighter aurora in that its latitude dependence is considerably less marked and the fact that it is derived from much lower energy states of atoms and molecules. Information is much more scattered but a moderately consistent picture is available. We will only consider the dayglow in the range of wavelengths observable by eye (Wallace and McElroy, 1968), an artificial restriction but one which nevertheless includes a variety of examples of the chemistry of the high atmosphere.

The principal emissions in the visual airglow arise from nitrogen,

oxygen, and sodium and the wave lengths and emitting species are listed in Table 1. There is a possible connection between the red and green oxygen emission since they may result from a cascade process of the type

$$O\,(^1S)\ \xrightarrow[\text{Green}]{5577A}\ O\,^1D\ \xrightarrow[\text{Red}]{6300}\ O\,^3P$$

We note however that the red lines are emitted from altitudes around 200 km whereas the green lines originate at about 100 km, with no conclusive evidence for 5577A emission above 150 km.

$$O_2\,(^2\Pi_g) + e \rightarrow O\,(^3P) + O\,(^1D) \qquad \text{(g)}$$

$$O_2\,(^2\Pi_g) + e \rightarrow O\,(^1D) \quad O\,(^1D) \qquad \text{(h)}$$

$$O_2\,(^2\Pi_g) + e \rightarrow O\,(^1D) + O\,(^1S) \qquad \text{(i)}$$

Fig. 5. Consequences of the recombination of O_2 which produce O^1D.

The basic problem was to consider the mechanisms by which these energetic species are produced. There are several possibilities

(1) Ionic Recombination

In reactions of the type

$$XY^+ - e \rightarrow X + Y$$

the products X and Y may be formed in a variety of excited electronic states, we will be interested in those leading to N^2D atomic nitrogen and O^1S and ^1D atomic oxygen.

The recombination of O_2 can yield a variety of consequences as in Fig. 5 where we list only those producing O^1D. This set of processes is a most appealing mechanism for 6300A production. The absence of green emission at 200 km suggests that O^1S production is small and that (i) is probably less important. The altitude ob-

servations also suggest that we can neglect quenching of O^1D by collisions so that the emission rate will be closely related to the recombination rate. The principal problems lie in the electron density estimates required for rate calculations. (2) Fluorescence and Resonant Scattering.

These processes involve the re-emission of energy absorbed as solar photons. If absorbed and emitted photons are of the same wavelength, we refer to resonant scattering; the more general case involving a wave length change is called fluorescence. The abundances of O and N are such that the fluorescence contributes to 5200A and 5577A emissions are ineligible. There could be a contribution to 6300A due to resonant scattering at lower altitudes but quenching, which is extremely important in this case, reduces it to a minor contribution. The 3914A N_2^+ emission however is entirely different and resonant scattering of sunlight is the principal source for 3914A emission in the twilight and day air-glow.

(3) Photodissociation

The absorption of solar radiation followed by the production of excited fragments is a possible mechanism for the excitation of atomic oxygen and nitrogen. Examination of the absorption efficiencies however indicates that only minor amounts of O (^1S) O (^1D) and N (^2D) can be expected from this source.

(4) Chemical Processes

Two chemical processes appear to be sources of air-glow:

(i) The three body reaction between oxygen atoms

$$O + O + O \rightarrow O_2 + O\ (^1S)$$

(ii) Ion atom interchange

$$N_2 + (^2\Sigma g^+) + O\ (^3P) \rightarrow NO\ (^1\Sigma^+) + N\ (^2D)$$

There is avast quantity of chemical energy stored in the atmosphere near 100 km in the form of oxygen atoms, about 5×10^{18} atoms in a centimetre square column, corresponding to about 2×10^{17} ergs cm^{-2}. The association of these atoms is a major source of 5577A especially in the night glow. Production of O (^1D) is also possible but the collision rate is such that quenching reduces 6300A emission to a negligible level.

The 5200A emission from ^2D may be produced by reaction (ii). Other reactions such as

$$O + O + N \rightarrow O_2 + N^2D$$
$$O_2^* + N \rightarrow O_2 + N^2D$$

have been proposed but any process involving atomic nitrogen as a reagent can only make a small contribution because of the low atmospheric density of this particular species.

(5) Electrons

When solar radiation ionizes the atmosphere, electrons are produced and some of these may initially have considerable amounts of kinetic energy. We may evaluate the effects of the fluxes provided we know the energy distribution function either as a result of experiment or from theoretical considerations. It is convenient to split the population into two groups, the quasi-thermal electrons and fast photo electrons. Data on the quasi-thermal electron distribution has been obtained from rocket flights and the appropriate electron density-excitation rate calculations show that quasi-thermal electrons are a minor source for 6300A day glow. The photo electrons however are relatively important sources for 5577 and 3914A emissions and significant contributions to 6300A above 200 km. The analysis here is rather complex since it follows a sequence: solar radiation→absorption and photoionization→fast and thermalized electrons→electrons→target densities and excitation efficiencies→ luminescence.

It can be easily seen from the foregoing that the behavior of the moderately high atmosphere is the result of the interaction of almost every possible entity derived from oxygen and nitrogen molecules. A coherent explanation is beginning to emerge and with improved values for the natural constants of reaction efficiency and reagent density we will rapidly approach a deeper understanding of the dynamics of the protective sheath which encloses the earth.

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Many-Body Problems in Physics and Society

Harry S. Robertson

As we are becoming increasingly aware, many-people problems exist; indeed they seem to grow ever more complex and more subtly dangerous to our continued survival. My attitude toward these problems is that effective solutions to them are improbable, in the absence of quantitative theoretical understanding of the social processes involved. Empiric knowledge, to be sure, has carried us to our present societal state, just as it has served us well in the incipient stages of science and engineering. In the more advanced sciences, however, empiricism has been almost entirely supplanted by an understanding, developed quantitatively from fundamental principles. So must it be with sociology.

The problems usually studied by physicists are clean and simple when compared with those in the domain of sociology, but as the relatively simple problems yield to attack, increasingly complex ones arise to challenge us. One particular area of physics, many-body theory, approaches in philosophy, if not yet in complexity, the many-people problem. Here it is necessary to assume incomplete knowledge of the system being studied, to work with statistical theories, and to extract patterns of expected behavior in the presence of essential statistical uncertainties.

Quite a large variety of many-body problems have been solved, often by highly sophisticated mathematical techniques. My hope and expectation is that some of these already-solved problems could be recast into sociopolitical terms, to be used as preliminary steps in elucidating the many-people problem. The areas of physics that should become sources of applicable solved problems are statistical mechanics, thermodynamics, kinetic theory, solid-state physics, and plasma physics.

Physicists do not usually think professionally about problems of society, and their approaches are often regarded by sociologists as simplistic and naive. Sociologists, psychologists, and other behavioral scientists do not usually possess the mathematical tools or the generalized approach of the physicist. They frequently seem to attack problems by blending empirical approaches based on anecdotal data with an indeterminate measure of wishful thinking.

In the relatively few cases that I know of in which behavioral scientists have attempted to formulate and analyze mathematical models of some aspect of society, either the mathematical level of the model has been too elementary to be of much value, or the entire model scheme has been too complicated to yield a useful mathematical solution. Exactly the opposite attack is suggested here; namely, that we find many-body physics problems, already solved, that can be rephrased in terms of variables and parameters that are appropriate to many-body social problems, interpret the solutions in the new terms, and thus develop new insights and understandings of society.

One favorable aspect of this approach may be its effect on physics students. Despite the direct attacks on some of the pressing problems of our age (such as pollution, energy sources, water supply, noise control) that are among the traditional concerns of professional scientists and engineers, the present intellectual climate has so emphasized the urgency of eliminating war, poverty, and the ghetto that many capable individuals are neglecting the so-called hard sciences in favor of disciplines that are closer in their professional objectives to these problem areas. At the present stage of evolution of the social sciences, I should expect these mathematically-gifted individuals to become capable of greater contributions toward their development if they were to choose the indirect route through the discipline of physics. Socially conscious students presently in physics continue to express interest in the occasional use of their abilities in other areas; the possibility of providing a productive channel for these abilities, and the enhanced involvement of these students with the many-people problems of our age should lead to interesting and presumably beneficial results.

A word of warning is necessary: much of the mathematical development of social sciences will be nonsense. A major difficulty of physics is that of writing equations that correctly represent the characteristics of the system under study. In social sciences, this difficulty is usually much more profound. Therefore it will be necessary to begin with deliberately oversimplified models leading to solvable problems, with the full knowledge that the results are not to be applied directly to far more complex societal situations. Most of the nonsense will result from failure to recognize that essential oversimplifications may invalidate or seriously restrict the generality

of problem solutions. Scientists who do not appreciate the complexity of social problems, and behavioral scientists who might be overimpressed by mathematical dexterity are equally likely to be led astray.

OBJECTIVES OF MODEL STUDIES

The evident primary objective of a program of mathematical models of society is the quantitative analysis, understanding, and prediction of dynamic developments in society. When this objective is reached, many-people theory will have become a mature science; at present we must recognize the value of more modest goals.

While our ability to make quantitatively accurate theories of dynamic social processes is still being developed, it should be possible to acquire a higher conceptual understanding of these processes in terms of model studies. The evolution of a sociopolitical entity from one dynamic state to another can be studied in terms of models with adjustable parameters, a family of behavior patterns can be generated, and a qualitative assessment of the effects of these parameters can be used as a means of educating our intuitions. If then the qualitative behavior of the models can be made to agree with the observed behavior of a sociopolitical entity (herein called a *system*) by a particular choice of parameters, a means may be provided for educating the parameters in terms of the system properties, and progress will have been nade toward the primary goal.

Even from the qualitative guidance obtainable from simplified model studies, the evolution of imaginative and increasingly effective action programs may provide interim amelioration of the many-people problem. Furthermore, the development of theories in which the properties of the system are interdependent (as is usual in real systems) may lead to increasingly sophisticated diagnostic techniques, from which better action programs may evolve.

REQUIREMENTS FOR VALID, USEFUL MODELS

Several evident requirements of valid models may be listed, and the requirement that the models also be useful modifies the list, to exclude overcomplex models. First, the model system, or sociopolitical unit, must be identifiable, i.e., distinguishable from

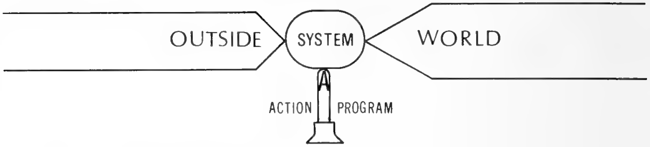

Fig. 1. Schematic diagram of a sociopolitical system, coupled to the outside world and subject to some kind of action program.

the rest of society, presumably by a set of characteristics or eigenproperties. Second, it must be made up of individuals with personalities (identifiable characteristics), subject to quantitative, perhaps statistical description. Some eigenproperties of the individuals (e.g., linguistic, economic, racial, or age grouping, in the case of social systems) may be those that characterize the system, but systems may be identified, for example, geographically, and comprise a broad spectrum of individual properties. In the corresponding physical systems, the eigenproperties need not resemble their societal counterparts; the important point is that each system can do *something*, its "thing", in an environmental setting, and the model study must be able to tell how well the system performs. Physical systems can be bells, oscillators, molecules, etc.

The third requirement is that the individuals must interact with each other and the rest of society. Descartes' proof of his existence, "cogito, ergo sum", should be modified to read "Interago, ergo sum". Without interaction, the system may as well not exist.

Finally, the interaction must lead to a problem that can be formulated mathematically and, at least approximately, solved. This requirement seems to imply the existence of a dynamics (as in the case of coupled harmonic oscillators) or a statistical dynamics (as in the study of stochastic processes).

A schematic diagram of the system, coupled to its surroundings and subject to some kind of forcing, is shown in Fig. 1.

Coupled-Oscillator Modelling

As an example of a physical model that can be applied to sociopolitical problems, I have chosen a perennial favorite of physicists, a system of coupled harmonic oscillators. The harmonic oscillator problem is unique in physics, in that it can apparently be solved

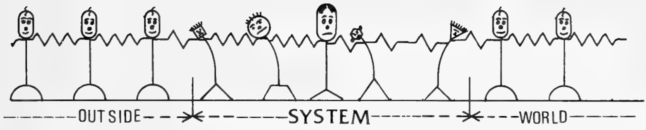

Fig. 2. Bound harmonic oscillator chain representing a collection of individual "people", the system, coupled to a statistically averaged outside world of basically similar people, interacting through nearest-neighbor coupling.

analytically in complete generality, both for classical and for quantum systems. Recently Huerta and I (1969, 1969a, 1970) have studied the approach to equilibrium of finite segments of infinite chains of coupled harmonic oscillators, the most interesting of which are weakly coupled to each other and harmonically bound to home positions. These oscillators can then behave as individuals in the short-term sense that each can oscillate at its own frequency and amplitude, at its own phase and with its own initial conditions. Yet in the long-term sense, each oscillator is weakly coupled to its neighbors, and its ultimate behavior is determined entirely by the initial conditions of remote members of the chain.

Thus the harmonic-oscillator chain can be used to model a set of interacting individuals, coupled to the surroundings. Members of the system can be chosen alike or different, as indicated schematically in Fig. 2. The individual oscillators can drift, if free to do so; they share energy, establish correlations, resonate when given the opportunity, and exhibit a certain predictable average behavior that can be extracted, in terms of the theory, from what would appear to be incomprehensible, random motion in the absence of the theory.

Oscillator systems are rich sources of model studies, with many solved problems in the literature. Action programs can easily be incorporated as external forcing, with the results interpretable as the response of the system to the forcing. Nonlinear behavior is accessible in terms of Van der Pol oscillators, nonlinear coupling, frictional resistance, and collisions, to name a few possibilities. So

far, however, very few applications have been made of these solved problems to non-physics situations.

In addition to those already mentioned, suggestive applicable results in physics include (a) the collective description of the motion of a system in terms of normal-mode oscillations, leading to almost-periodic oscillations of members of the system; (b) the evolution of a system to equilibrium with its surrounding; (c) the resonant response of individual members of a system to appropriate forcing; (d) the influence of the surroundings on the system and *vice versa;* and (e) the loss of certainty, increase of entropy or of missing pertinent information as the system evolves.

One exciting nonphysics application of coupled-oscillator modelling is Brian Goodwin's (1963, 1969) recent work at Sussex on biological cell dynamics in terms of the statistical mechanics of coupled oscillators. He develops a "talandic" temperature (*talandic* is a hellenism implying a relationship to oscillators), and a thermodynamics of populations of mRNA and protein molecules. His biochemical oscillators interact with differing coupling strengths. Resonant interactions, entrainment, and other sometimes-nonlinear effects are important in Goodwin's theory. He is able to uncouple certain conjectured biochemical oscillators by pulsing living systems, providing an example of a sophisticated diagnostic technique. His model regards the biological oscillators as real, rather than merely as entities having convenient eigenproperties.

ATTAINMENT OF QUANTITATIVE UNDERSTANDING

While it may be evident that coupled-oscillator systems can be interpreted in sociopolitical terms with some possible qualitative insight derivable from the exercise, it is by no means evident that any useful quantitative understanding could result from such intrinsically simple models. Only experience will enlighten us.

If we expect to attain quantitative understanding, we must choose the model judiciously to match a convenient sociopolitical system. Then the parameters of the system must be established, probably by means of empirical procedures, since a sound basic theory is usually not available. (The empirical approaches of Green (1962, 1962a, 1965) appear to be extremely valuable at this point). As a final suggestion, once the model has been analyzed, the numerical data needed for a proper choice of parameters may

possibly be obtained by "shaking" the system and observing the response. Signal-to-noise ratio is an ever-present problem, and the ability to extract data on system parameters from low-level forcing of the system may be so limited that quantitative prediction is almost impossible.

CONCLUSIONS

It is possible to recast many-body problems in physics to resemble simple many-people problems. A variety of these problems have been and can be solved, either analytically or by computer. The solutions of the recast problems may provide behavioral scientists with new insights, concepts, diagnostic procedures, and improved understanding of many-people problems. The possible resultant interaction between the physical scientists and the social scientists might lead to concrete, useful advances toward the solution of many-people problems.

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A New Neogene Barnacle from South Florida

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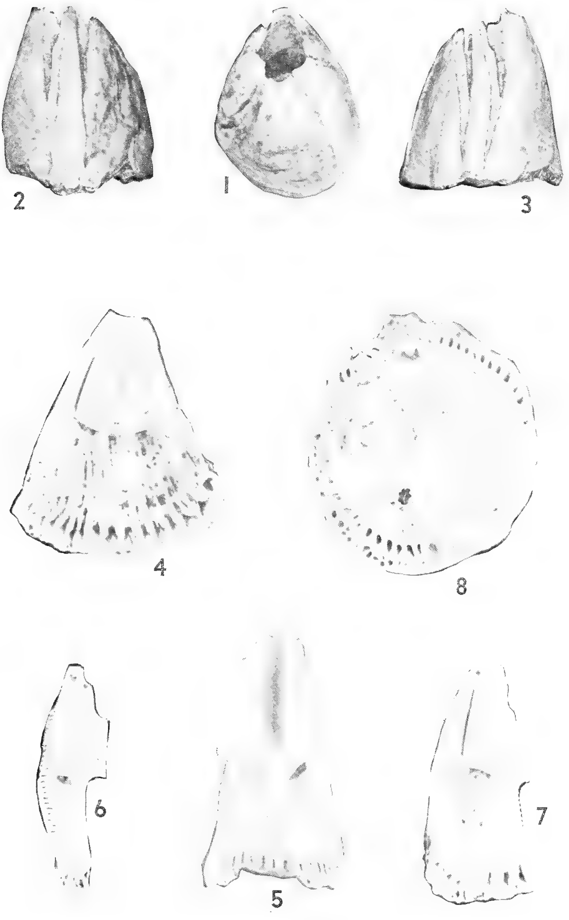
THE barnacle described below was obtained from the Pinecrest Sand (uppermost member of the Tamiami Formation) in a large quarry 3-4 miles east of Sarasota, Sarasota County, Florida. The type and only specimen was recovered from loose sand adherent to some large corals, collected 29 January 1970 by Dr. Harbans Puri of the Florida Bureau of Geology and donated to the Department of Geology, Florida State University.

Balanus sarasotaensis, n. sp.

Description. The shell (Figs. 1-8) is small, somewhat fragile, elongate-conical, subcircular at the base. The carinal end is erect, hardly convex in longitudinal profile, a little taller than the rostral end. The rostrum is broadly triangular, moderately convex, and wider than all of the other compartments. The lateral and carinolateral compartments are steeply sloping and nearly straight, the carinolaterals by far the narrowest of all compartments. The orifice is obtusely diamond-shaped, elongated toward the carina, and about two-fifths the length of the shell at the base. The peritreme is rather strongly toothed by the summits of the compartments. All of the compartments are separated markedly above the middle, the amount decreasing therefrom to the base where there is a mere cleft.

The parietes are thick, tubular within, and broadly triangular except for the carinolaterals which are very narrow. The rostral paries is the widest, the width decreasing successively on the carina, laterals and carinolaterals. The external surface of the paries is marked by faint radial or oblique rugosities, crossed by crowded sinuous concentric wrinkles. In places fine longitudinal and transverse lineations are discerned under the microscope. The surface itself is somewhat shiny, the ground color tan, rayed by interrupted stripes of light violet.

The radii are narrow, deeply sunken, slanted inward, and provided with strong transverse ridges, crenulated by short sturdy oblique denticles on the upper side of the ridges. The sutural margins of the compartments are similarly ridged, the oblique denticles



Figs. 1-8. Holotype of *Balanus sarasotaensis,* n. sp. Figs. 1-3, exterior of shell, × 3. Figs. 4-8, interior of shell, × 4. Fig. 4, rostrum; fig. 5, carina; fig. 6, carinolateral compartment; fig. 7, lateral compartment; fig. 8, basis.

of the opposed sutural edges situated on opposite sides of the ridges to receive the recipient grooves of the other. The alae are thin, narrow, and not slanted, thus forming a gape between them and the strongly slanted radii. The external surface of the alae is shiny and marked by transverse, closely spaced, microscopic striations.

The sheath extends about half way down the interior and is free at its lower margin. The inner surface is sculptured by sharp, slightly wavy, concentric riblets becoming more widely spaced below; on the carina and carinolateral compartments, but not on the others, there is a smaller riblet in each of the interspaces, these secondaries not reaching the lower margins of the sheath as do the primaries. The lateral margins of the sheath are raised, one margin slightly thicker than the opposite, both reinforced at the intercepts of the primary riblets. On the carina and carinolateral compartments, the primary riblets of the sheath proper continue onto the alar extension of the sheath as vertical striae.

The inner wall of the compartments below the base of the sheath is constructed of flexuous longitudinal ribs, each joining a lamina at the base of the paries. The ribs are slanted and strongly striate near the base and denticulate where they join the basal laminae. The ribs and laminae form the walls of the parietal tubes which are more or less quadrangular in form. There are 18 tubes on the rostrum, 13 on the carina, 8 on the laterals, and 5 on the carinolaterals. Partitioning septa within the parietal tubes have not been observed.

The basis is calcareous and is adherent to the exterior of a *Crepidula* resembling the Miocene to Recent *Crepidula aculeata* Gmelin. The under, or attached surface of the basis consists, at least at the margin, of rather coarse, closely spaced, concentric ridges; in the interior, the basis is multicellular around the periphery, and most of the surface is covered by small ridgelets radiating and swirling away from an off-centered nucleus. There seem to be as many ridgelets as there are parietal tubes in the shell.

The opercular values have not been seen.

Measurements. Type specimen (SP-2a): height of shell at carinal end 9.0 mm, rostral end 6.5 mm.; diameters of basis 8.5 mm $\times$7.6 mm.; length of orifice 3.5 mm.; height of sheath on carina 5.0 mm, on rostrum 4.2 mm.; width of paries at base: rostrum 7.5 mm, carina 5.5 mm, laterals 4.0 mm, carinolaterals 2.0 mm and 3.0 mm.

Type specimen. SP-2a is presently conserved in the Department of Geology, Florida State University. After photographing the whole specimen, the shell was disarticulated. The type now consists of the discrete compartments and the basis.

Type locality. Pinecrest Sand Member of Tamiami Formation, in large excavation (Warren Brothers Pits) 3-4 miles east of Sarasota, Sarasota County, Florida. Knowledge of the exact location awaits a detailed survey.

Comparisons. The new species, *Balanus sarasotaensis,* is distinguished by the marked separation of the compartments above the middle of the shell, by the gape between the radii and alae, by the strongly ridged, inward slanting radii, and by the very narrow carinolateral compartments. It differs from all of the Tertiary and Pleistocene barnacles hitherto recorded from Florida by Ross and Newman (1967, pp. 18,19), although among those there is a superficial resemblance to *Balanus bloxhamensis* Weisbord (1965, pp. 48,49, pl. 12, figs. 5,6) from the Jackson Bluff Formation of North Florida, and to the late Miocene *Balanus tamiamiensis* Ross (1964, pp. 271-274, fig. 1) from the Tamiami Formation of South Florida. *Balanus withersi* Pilsbry (1930, pp. 429-431, pl. 36, figs. 1-27) from the Miocene near Shiloh, New Jersey is also somewhat similar, but the parietes of that are strongly ribbed and made up of fewer parietal tubes with widely spaced transverse septa.

AGE OF THE TYPE LOCALITY

From the type locality of *Balanus sarasotaensis,* Puri (personal communication) has identified the gastropod *Cancellaria propevenusta* Mansfield (1930, pp. 47,48, pl. 17, fig. 2), and as that is a guide fossil for the upper sand member of the Jackson Bluff Formation in North Florida, the general equivalence of the Pinecrest and Jackson Bluff Formation is suggested. This correlation is further supported by the occurrence of the coral *Septastrea marylandica* (Conrad) (see Vaughan, 1904, pp. 444-447, pls. 126-129) identified by the present writer in both formations. Additional evidence is provided by Muriel E. Hunter (1968, pp. 441,444,449) who, on the basis of certain distinctive species of *Pecten* and other molluscan guide fossils, has established concurrent range zones of the Pinecrest Sand, Ochopee Limestone, and Buckingham Limestone in the upper part of the Tamiami Formation of South Florida, and states

they are probably equivalent to the Jackson Bluff Formation of North Florida, to the Duplin Marl of South and North Carolina, and to the Yorktown Formation of Virginia.

The Tamiami Formation, as re-defined by Parker and others (1955) has a total thickness of about 150 feet, and is considered by Olsson (1968, p. 7), Hunter, and Puri to be late Miocene in age as adduced primarily from Mollusca. The Pinecrest Sand, in the upper part of the Tamiami Formation is at least 6 feet thick at the type locality (near 40-mile Bend, Dade County, Florida, in a ditch along state road 94, Sect. 25, T. 54 S., R. 34 E.) where it consists of unconsolidated medium-coarse sand with abundant, well preserved marine fossils and occasional traces of silt-size black phosphate grains. The excavation east of Sarasota is located 144 miles northwest of the type locality of the Pinecrest Sand. The strata in the excavation containing the gastropod *Cancellaria propevenusta* Mansfield, the coral *Septastrea marylandica* (Conrad, 1841), and the barnacle *Balanus sarasotaensis* n. sp., are placed by Puri and Vanstrum (1968, p. 84) in the Pinecrest Sand, the age of which is presumed to be no older than late Miocene.

In the same excavation, lying above the Pinecrest, are soft fossiliferous sands containing numerous specimens of the bivalve *Cyrtopleura costata* (Linnaeus). This stratum is referred to as the *Cyrtopleura costata* faunizone by Puri and Vanstrum (1968, p. 86) which they indicate is pre-Nebraskan and probably Pliocene in age.

The geologic range of *Cyrtopleura costata* is Pliocene to Recent, and the species has been recorded in the buried Lower Pliocene deposit of North St. Petersburg, Florida, by Olsson and Harbison (1953, p. 152). That deposit, located about 36 miles north-northwest of the East Sarasota excavation, is a remarkable accumulation of shells, 5 feet or more in thickness, lying 10-15 feet below the Quaternary surface of Pinellas Park at a spot 900 feet east of 9th Street and a short distance south of 70th Avenue, North St. Petersburg, west of Tampa Bay. This exceedingly rich "coquina", mixed with a little bluish silt, was uncovered by dredging on 23 February 1959 when I was privileged to see it for an hour or so before the overburden, saturated with seeping water from below, slumped back over it. The deposit was unquestionably in place and packed with excellently preserved shells. It is my understanding that Olsson and Harbison's fossils were obtained from this very deposit

unearthed in previous dredgings and strewn on the surface near by. According to Olsson and Harbison (1953, p. 25), the deposit contains 517 species of mollusks (493 of them marine) of which 34 per cent or so are also Recent. Reciprocally, 66 per cent are extinct, and on this basis a Pliocene age was assigned to it by them. In my view (see Weisbord, 1962, footnote p. 69) the age, again based on the extinction per cent of the Mollusca, is not younger than early Pliocene.

In summary it would appear that the Pinecrest Sand Member of the Tamiami Formation is late Miocene in age and the *Cyrtopleura* faunizone lying above it is Pliocene. Both determinations are based for the most part on the evidence derived from Mollusca which are largely benthonic in habitat. On the other hand, planktonic Foraminiferida, which by virtue of their universality are important age indicators or biologic chronometers, are indicating that the established Miocene of Florida and the Caribbean region is to be correlated with the Pliocene and even the Pleistocene zones of the standard section in Italy. Thus the Jackson Bluff Formation of Florida and the Bowden Formation of Jamaica, both veritable bastions of the molluscan Miocene, are today considered Pliocene and Pleistocene by some advocates of the plankton. To reconcile the differences there seems to be developing a dual system of nomenclature for the epochs of the Neogene; an old, established one based on the Mollusca, and a newer yet viable one based on the planktonic Foraminiferida.

ACKNOWLEDGMENTS

The photographs of the exterior of the type of *Balanus sarasotaensis* were taken and processed by Gerritt Mulders of Tallahassee, the interior by Dr. Fritz Cramer, Department of Geology, Florida State University.

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Trophic Relationships in the Water Hyacinth Community

Keith L. Hansen, Edward G. Ruby, and Robert L. Thompson

Since its introduction to Florida in 1835 (Goin, 1943), the water hyacinth, *Eichhornia crassipes* (Mart.) Solms, has been considered both a blessing and a curse. From the negative standpoint, the rapid growth of this mat-forming species serves as a menace to navigation, irrigation, drainage, and flood-control through sheer blockage. Eradication of the hyacinth has proved both difficult and expensive. On the positive side, this floating form with its extensive arborescent root mass provides a natural shelter and microhabitat which abounds in a rich associated fauna. Some naturalists are now advocating retaining a controlled border of hyacinths because of its support of game fishes and their food organisms.

The purpose of the present study was to make a preliminary investigation of some of the trophic relationships between the vertebrate and invertebrate members of the hyacinth community. It was the intent of the study to establish some food chains using varying techniques including a radioactive tracer (P-32), stomach analyses, and direct feeding observation.

One critical question asked was whether the hyacinth itself contributed as a significant producer in the food web. A second specific problem involved the precise role of the talitrid amphipod, *Hyalella azteca.*

Materials and Methods

Biota. Larger animals used in the study were collected in 10 and 15 foot minnow-seines from marginally located hyacinths in shallow water of the St. Johns River and its tributaries. Amphipod crustaceans (scuds), *Hyalella azteca,* were easily taken by rapidly plunging the roots of a hyacinth plant up and down in a small bucket of water. Small hyacinths bearing 6-10 leaves were selected for feeding and isotope experimentation.

Radiological Techniques. The general procedure for this aspect of the study was to introduce the radionuclide, phosphorus-32, in aqueous solution to both hyacinths and scuds. Both forms showed a rapid uptake of the isotope as soon as 24 hours. These two species were used as the starting point for the majority of feed-

ing experiments. For isotope counting, experimental animals were sectioned into pre-weighed planchets, dried thoroughly under an infra-red lamp, and ashed in an oven at 600 C. The ash was weighed and then counted by a beta-scintillation detector.

Feeding Experimentation. The laboratory studies were conducted with invertebrate and vertebrate species in small aquaria and plastic containers. Experimental forms were separated from controls by hardware cloth covered with 1 mm mesh nylon. Aeration was used for those species requiring high oxygen tension. Feeding experimentation in the field employed flow-through cages constructed of a wooden frame ($3 \times 2 \times 2$ feet) enclosed by aluminum screen and 1 mm nylon-mesh cloth. These cages were used in a protected area of the St. John's River.

RESULTS

The study consisted of two major portions, namely the laboratory investigation and a field endeavor. Laboratory studies were primarily concentrated upon individual feeding experimentation on hyacinth roots or scuds. In the field operation varying species combinations were placed in the cages to determine differing feeding interactions.

Radioactive Tracer Evidence. The radiological criteria for establishing certain species as definite hyacinth or scud feeders was based upon sufficient numbers of laboratory and field tests showing significantly higher P-32 levels in the experimental as contrasted to the control groups. Strongly reliable radiological evidence for four herbivorous species feeding upon hyacinth roots is presented in Table 1. Table 2 offers good evidence that four primary carnivore

TABLE 1

Phosphorus-32 levels in *Eichhornia crassipes* feeders

Species	Laboratory		Field	
	No. Tests	Av. $\times 10^{-3}\mu c/gm$ (controls=0.0)	No. Tests	Av. $\times 10^{-3}\mu c/gm$ (controls=0.0)
Hyalella azteca	6	412.3	2	331.0
Procambarus fallax	1	11.6	3	43.3
Pomacea paludosa	1	15.1	3	23.2
Hyla cinerea cinerea (tadpole)	—	—	1	360.0

TABLE 2

Phosphorus-32 levels in *Hyalella azteca* feeders

Species	Laboratory		Field	
	No. Tests	Av.$\times 10^{-3}\mu c/gm$ (controls=0.0)	No. Tests	Av.$\times 10^{-3}\mu c/gm$ (controls=0.0)
Ictalurus nebulosus marmoratus	3	13.0	2	21.4
Lepomis punctatus punctatus	4	22.7	3	20.4
Lepomis macrochirus purpurescens	5	24.7	2	22.3
Enneacanthus gloriosus	10	37.9	2	12.6

TABLE 3

Phosphorus-32 levels in possible *Hyalella axteca* feeders

Species	Laboratory		Field	
	No. Tests	Av.$\times 10^{-3}\mu c/gm$ (controls=0.0)	No. Tests	Av.$\times 10^{-3}\mu c/gm$ (controls=0.0)
Palaemonetes paludosus	5	7.3	1	0.5
Procambarus fallax	5	8.7	3	1.9
Ranatra fusca	8	2.4	2	22.5
Anisoptera larva	5	16.4	—	—
Lucania goodei	3	17.4	1	38.2
Fundulus chrysotus	2	2.7	1	6.3
Mollienesia latipinna	1	39.1	—	—
Pomoxis nigromaculatus	5	16.4	—	—

piscine species feed upon the scud. Table 3 suggests a carnivorous role for eight forms, but additional study is needed to confirm these forms as certain scud feeders. In the tabular presentation, distinction is made between the laboratory and field situation.

Stomach Analysis and Observation. Some data were obtained from limited stomach analyses as shown in Table 4. Direct observation of aquarium feeding showed that the stumpknocker (*Lepomis punctatus punctatus*) and southern brown bullhead (*Ictalurus nebulosus marmoratus*) captured scuds in the open water. The stumpknocker was quite adept at catching scuds. Water scorpions (*Ranatra fusca*) and an unidentified anisopteran larva were ob-

TABLE 4
Stomach analyses

Individuals Examined	Species	Significant stomach contents
20	*Fundulus chrysotus*	1 anisopteran larva; 1 scud; small aquatic beetles; unidentified arthropod parts
10	*Gambusia affinis holbrooki*	3 with desmids & blue-green algae; beetle larva; unidentified arthropod parts
6	Anisopteran larva	Unidentified arthropod parts
1	*Chaenobryttus coronarius*	Small fish remains
2	*Lepomis p. punctatus*	1 freshwater shrimp; small aquatic beetles
1	*Lepomis macrochirus purpurescens*	1 freshwater shrimp

served attempting to capture scuds, but the amphipods often escaped the grasping limbs and mouth parts.

Discussion

A partial food web (Fig. 1) has been constructed as a composite from all data collected in the study. It is incomplete as concerns

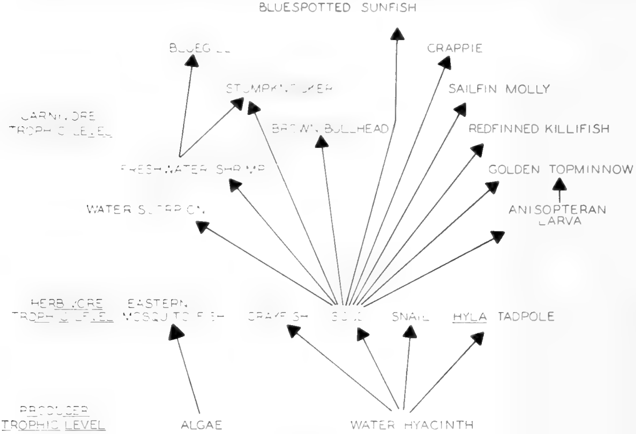

Fig. 1. Partial food-web suggested for the water hyacinth community from P-32 evidence and stomach analyses.

the total feeding relationships of the total hyacinth community. Although micro-producers as phytoplankton undoubtedly play a role in the nutrition of some members of the hyacinth community, phytoplankton has not been considered in the present study.

Producer Trophic Level. Although the water hyacinth is certainly the major macro-producer in the community, other occasional associates would include such floaters as water lettuce (*Pistia stratiotes*), water fern (*Salvinia rotundifolia*), and duckweeds (*Lemna minor, Spirodela polyrhiza*); submergents as water milfoil (*Myriophyllum* sp.) and alligator weed (*Alternanthera philoxeroides*); and emergents as cattail (*Typha latifolia*), pickeral weed (*Pontederia lanceolata*), and grasses.

Herbivore Trophic Level. The principal herbivore of the hyacinth community, feeding specifically upon hyacinth roots, is the scud (*Hyalella azteca*). Numerically, the scud is the dominant metazoan animal in the water hyacinth community as also verified by the studies of Katz (1967) and O'Hara (1967). From a total of 32 hyacinth plants examined, an average number of 66 scuds per hyacinth was counted. Amphipods are generally recognized to be detritus feeders or scavengers (Barnes, 1968). Although we have observed *Hyalella* feeding upon normal hyacinth root tissue, the question arose as to whether it might prefer decomposing hyacinth roots. Scuds were fed normal and decomposing hyacinth roots tagged with P-32. Those individuals feeding upon the decaying tissue showed 1.9 times higher radiation count.

Although omnivorous, the crayfish *Procambarus fallax* could be observed hanging from and crawling among hyacinth roots where it appeared to browse and feed directly upon the roots. The P-32 tracer evidence for the crayfish corroborated this observation.

Although the snail *Pomacea paludosa* and tadpole of *Hyla cinerea cinerea* showed a high concentration of P-32 uptake, these forms may possibly browse upon the periphyton (aufwuchs) growing on the hyacinth roots. Further study is necessary to determine the precise source of nutrition for these two species.

Carnivore Trophic Level. The majority of the organisms studied gave evidence which placed them in the carnivore feeding level. These include the freshwater shrimp (*Palaemonetes paludosus*), water scorpion (*Ranatra fusca*), an anisopteran larva, southern

brown bullhead (*Ictalurus nebulosus marmoratus*), redfinned killifish (*Lucania goodei*), golden topminnow (*Fundulus chrysotus*), stumpknocker (*Lepomis punctatus punctatus*), bluegill (*Lepomis macrochirus purpurescens*), bluespotted sunfish (*Enneacanthus gloriosus*), and crappie (*Pomoxis nigromaculatus*).

In addition to each of these forms showing evidence of feeding upon the herbivorous scud, the golden topminnow feeds upon anisopteran larvae and both the bluegill and stumpknocker feed upon the freshwater shrimp.

One numerically important member of the hyacinth community is the water bug, *Belostoma* sp. No evidence was forthcoming in this study which indicated it to be either a hyacinth or scud feeder.

SUMMARY

A study of the trophic relationships in the water hyacinth community was conducted using biota from the St. John River Drainage near DeLand, Florida, from June 16 through August 8, 1969.

The water hyacinth is a superior experimental plant for radionuclide absorption from an aqueous solution. The amphipod *Hyalella azteca* is the basic herbivore of the water hyacinth community. This species browses upon the root system of the producer hyacinth. Feeding observation and P-32 tracer studies indicate that the following species feed directly upon water hyacinth roots: *Hyalella azteca*, *Pomacea paludosa*, *Procambarus fallax*, and *Hyla cinerea cinerea* (tadpole). Feeding observation and radioisotope experimentation gave evidence that the amphipod *Hyalella azteca* serves as food for the following piscine species: *Ictalurus nebulosus marmoratus*, *Lepomis punctatus punctatus*, *Lepomis macrochirus purpurescens*, and *Enneacanthus gloriosus*. Preliminary evidence using P-32 tagged *Hyalella* indicates that the following forms feed upon the amphipod: *Palaemonetes paludosus*, *Procambarus fallax*, *Ranatra fusca*, an anisopteran larva, *Lucania goodei*, *Fundulus chrysotus*, *Mollienesia latipinna*, and *Pomoxis nigromaculatus*.

A partial food-web of the water hyacinth community, constructed as a composite from all data, shows two producers, five herbivores, and 11 carnivores.

ACKNOWLEDGMENTS

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A New Troglobitic Crayfish from Florida

Horton H. Hobbs, Jr.

With the discovery of the new species described herein from a well in Dade County, Florida, seven troglobitic crayfishes, representing three genera, are known to occur within the state. The monotypic genus *Troglocambarus* is endemic in the karst area of the peninsula. The genus *Cambarus*, of which there are six or perhaps seven troglobites (*C. cahni* is a questionable troglobitic species; Hobbs and Barr, 1960), is represented by only one Floridian species in Jackson County and southwestern Georgia, the remaining members frequenting subterranean waters of Alabama, Arkansas, Missouri, and Tennessee. Five of the eight known spelean species and subspecies of the genus *Procambarus* are Floridian endemics; the other three occur in Alabama, Cuba, and Mexico. Only one other crayfish genus, *Orconectes*, is represented among the troglobitic crayfishes, and six species and subspecies belonging to it are found in the limestone area extending from northern Alabama to southern Indiana (Hobbs and Barr, in press).

To aid in the recognition of the troglobitic crayfishes of Florida, a key to those occurring in the State is appended to the description of the new species. Summaries of our knowledge of the previously described Floridian species are recorded by Hobbs, 1942b, 1958; Hobbs and Barr, 1960; and Warren, 1961.

All of the specimens of the new troglobite were obtained from a trap at the outlet of a motorized pump at the Little Bird Nursery in Miami and were forwarded to me by Billy R. Drummond and George C. Miller, who together with Henry De Maine and David Burton, former and present proprietors of the nursery, became interested in the animals, including amphipods and isopods, which appeared in the trap. I wish to thank these gentlemen for permitting me to describe this crayfish which is named in honor of Mr. Miller, a long-time friend and fellow student of crayfishes. I am also grateful to him and to Fenner A. Chace, Jr. for their criticisms of the manuscript. Finally, I acknowledge, with appreciation, the gift of three specimens (1 ♂ I, 1 ♂ II, 1 ♀) of *Procambarus pallidus* from Suwannee County by William F. Smith-Vaniz. These specimens were collected by him from an un-named sink in the Peacock

Slough system, three miles east of Lauraville, and serve further to close the gap in the apparent discontinuous range of the species.

Procambarus milleri, new species

Diagnosis. Body without pigment, eyes large but with pigment confined to small, faceted, distal disc. Rostrum without marginal spines or tubercles, and base of acumen continuous with rostral margins. Areola 33-36.6 per cent of entire length of carapace, and five to six times longer than wide. Cervical spines lacking. Suborbital angle rudimentary. Postorbital ridges lacking tubercles or spines. Antennal scale approximately 2.3 times longer than wide, broadest about midlength. Mesial surface of palm of chela with irregular row of 9-11 tubercles, and both fingers provided with moderately well developed longitudinal ridges. Ischia of third and fourth pereiopods with simple hooks. First pleopods asymmetrical with rounded shoulder on cephalic surfaces, provided with subterminal setae, and reaching cephalad to coxae of second pereiopods; distal extremity bearing (1) long, slender, sinuous mesial process reaching clearly beyond other terminal elements, (2) slender, moderately long cephalic process arising from cephalomesial surface and extending distally almost as far as tip of central projection, (3) corneous, distally-directed, lanceolate central projection arising from cephalomesial surface of caudal knob, and (4) prolonged rounded caudal knob, caudal process lacking. Adult female unknown.

Holotypic Male, Form I. Body subovate, compressed laterally. Abdomen narrower than thorax (5.2 and 5.7 mm). Width of carapace less than height at caudodorsal margin of cervical groove (5.7 and 6.5 mm). Areola 6.0 times longer than wide with two or three punctations across narrowest part. Cephalic section of carapace 1.7 times as long as areola (length 36.6 per cent of entire length of carapace). Rostrum excavate dorsally with unthickened convergent margins lacking spines or tubercles; upper surface of rostrum concave with usual submarginal row of setiferous punctations and others between; acumen not delimited basally. Subrostral ridges moderately well developed but evident in dorsal aspect only in caudal orbital region. Postorbital ridges moderately prominent, grooved dorsolaterally, and lacking spines or tubercles. Suborbital

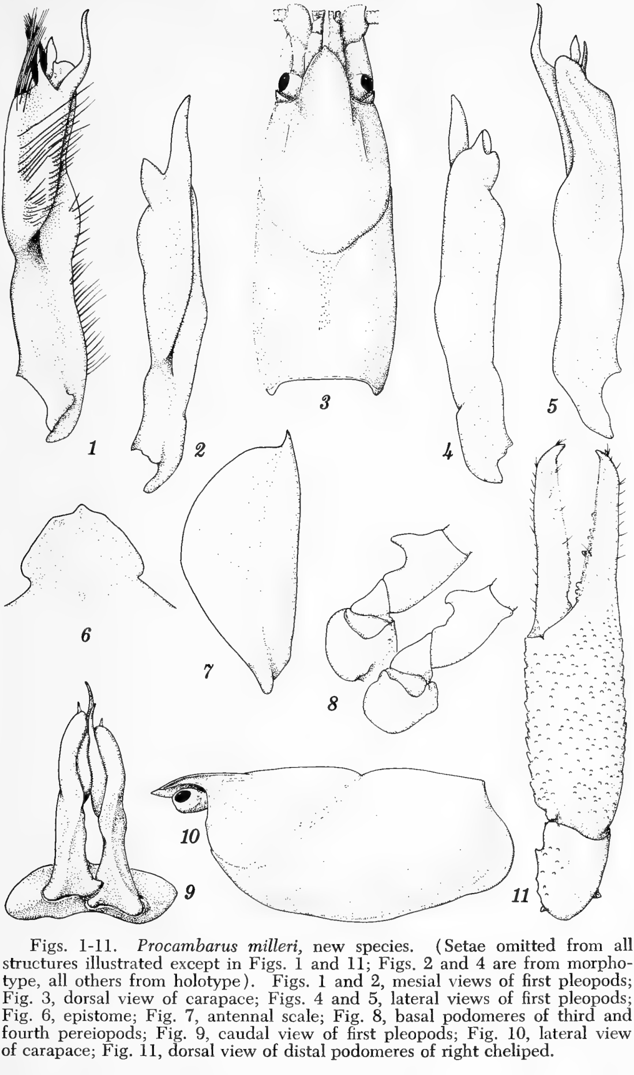
TABLE 1

Measurements (mm) of *Procambarus milleri*

	Holotype	Morphotype
Carapace:		
Height	6.5	3.8
Width	5.7	3.5
Length	13.1	7.8
Areola:		
Width	0.8	0.3
Length	4.8	2.6
Rostrum:		
Width	2.4	1.3
Length	2.8	1.9
Right Chela:		
Length of inner margin of palm	6.2	2.2
Width of palm	3.5	1.9
Length of outer margin of chela	13.7	5.2
Length of dactyl	6.6	2.6

angle and branchiostegal spine almost obsolete. Carapace punctate dorsally and weakly granulate laterally, cervical spines and enlarged cervical tubercles lacking. Abdomen longer than carapace (15.2 and 13.8 mm). Cephalic section of telson with three spines in each caudolateral corner. Cephalic portion of epistome (Fig. 6) somewhat resembling isosceles rhomboid with small cephalomedian projection, mostly plane with slightly elevated (ventrally) margins. Antennules of usual form with moderately prominent spine on ventral surface near midlength. Antennae broken but probably extending caudad at least as far as telson. Antennal scale (Fig. 7) 2.3 times longer than wide, greatest width about midlength, with lamellar area much broader than thickened lateral portion; latter terminating in comparatively short spine.

Right chela (Fig. 11) elongate, subovate in cross section, not strongly depressed. Mesial surface of palm with irregular row of 11 tubercles, lateral margin with subserrate row of tubercles, and upper and lower surfaces tuberculate; lower surface with prominent tubercle distolateral to articular condyle at base of dactyl. Fixed finger with submedian longitudinal ridge dorsally and ventrally, both flanked by setiferous punctations; opposable margin with two rows of tubercles, dorsal one consisting of 11 situated along proximal three-fifths of finger with third from base largest,



Figs. 1-11. *Procambarus milleri*, new species. (Setae omitted from all structures illustrated except in Figs. 1 and 11; Figs. 2 and 4 are from morphotype, all others from holotype). Figs. 1 and 2, mesial views of first pleopods; Fig. 3, dorsal view of carapace; Figs. 4 and 5, lateral views of first pleopods; Fig. 6, epistome; Fig. 7, antennal scale; Fig. 8, basal podomeres of third and fourth pereiopods; Fig. 9, caudal view of first pleopods; Fig. 10, lateral view of carapace; Fig. 11, dorsal view of distal podomeres of right cheliped.

ventral row of four tubercles, most proximal largest, situated along middle half of finger, minute denticles studding surface between and distal to tubercles. Dactyl with weak dorsal and ventral submedian longitudinal ridges flanked by setiferous punctations; mesial surface with row of similar punctations; opposable margin with single row of nine small tubercles along proximal half of finger, larger one below row between level of fourth and fifth tubercle, and with minute denticles interspersed between tubercles and extending almost to corneous tip of finger.

Carpus of right cheliped longer than broad (3.5 and 2.4 mm) with mesial and dorsomesial surfaces tuberculate, and dorsolateral, lateral, and ventral surfaces mostly punctate; dorsal surface with shallow oblique depression; mesial surface with one conspicuously large, subacute tubercle, three smaller ones proximal to it, and one small one dorsodistally; lower distal margin with two spiniform tubercles, lateral one on ventrolateral articular condyle, and other, more mesially situated, with several smaller tubercles proximomesial to it.

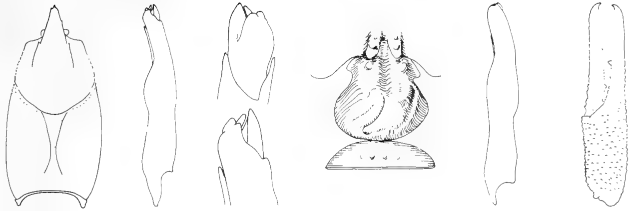
Merus of right cheliped punctate laterally, otherwise tuberculate; marginal ventral tubercles arranged in mesial and lateral rows of approximately 14 tubercles each. Ischium with three small tubercles.

Hooks on ischia of third and fourth pereiopods (Fig. 8) simple, extremities of neither approximating distal margin of corresponding basis. Coxa of fourth pereiopod inflated caudomesially but lacking distinct boss; that of fifth pereiopod with very prominent, caudomesial, oblique prominence compressed in longitudinal plane of body.

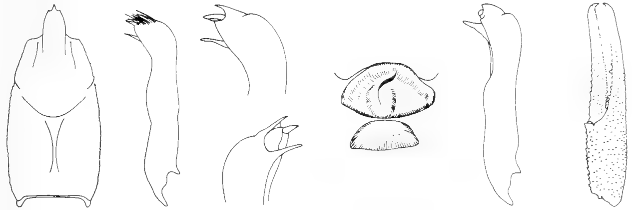
Sternum between second, third, and fourth pereiopods moderately shallow and bearing heavy fringe of setae on ventrolateral margins.

First pleopods (Figs. 1, 5, 9) as described in diagnosis.

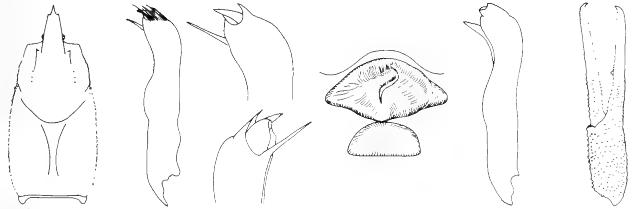
Morphotypic Male, Form II. Differs from holotype in following respects: rostrum more strongly acuminate; cephalic section of telson with only one spine in each caudolateral corner; mesial margin of palm of chela with only nine tubercles; opposable margin of fixed finger with only two prominent tubercles and that of dactyl with one; ventral surface of merus of cheliped with six or seven tu-



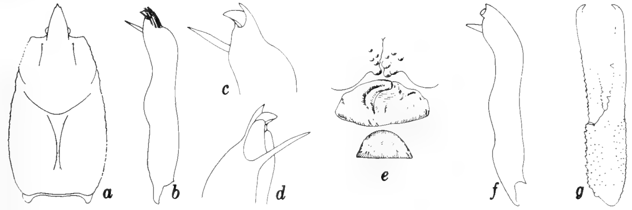
12. P. acherontis



13. P. l. lucifugus

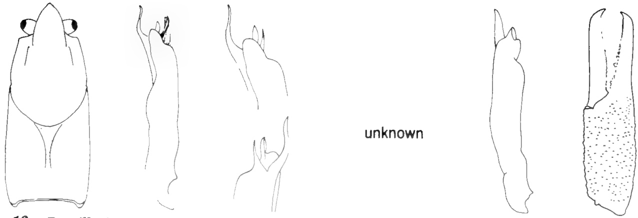


14. P. l. alachua

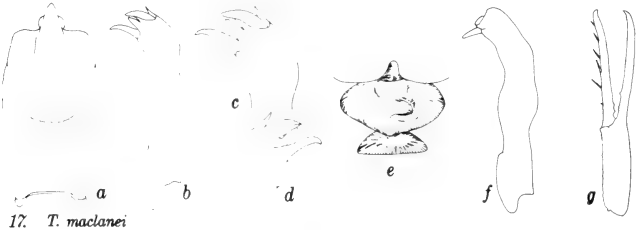


15. P. pallidus

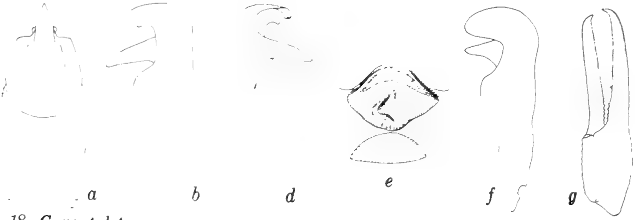
Figs. 12-15. Floridian troglobitic crayfishes. (Setae omitted from all structures illustrated except subterminal ones on b). a, dorsal view of carapace; b, lateral view of first pleopod of first form male; c, mesial view of distal portion of same; d, lateral view of distal portion of same; e, annulus ventralis; f, lateral view of first pleopod of second form male; g, dorsal view of chela of first form male.



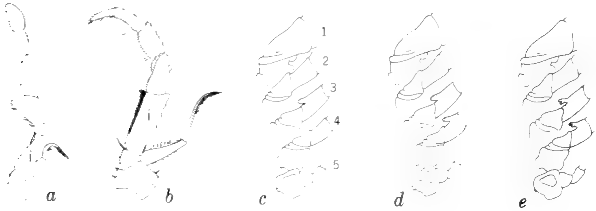
16. *P. milleri*



17. *T. maclanei*



18. *C. cryptodytes*



19.

bercles in each row; ischia of third and fourth pereiopods with scarcely trace of hooks. See measurements.

First pleopods (Figs. 2, 4) much more nearly symmetrical than in holotype and with oblique suture near base. Terminal elements non-corneous, proportionately larger and heavier (except for caudal knob), but situated and directed as their counterparts in holotype.

Type-locality. Well at Little Bird Nursery and Garden Store at 8427 Bird Road, Miami, Dade County, Florida (Sec. 15, Twp. 54S, R. 40E). The well is 22 feet in depth and is provided with an 18 foot casing.

Types. The holotypic male, form I (No. 131257), and morphotypic male, form II (No. 131258), are deposited together with the paratypes (five males, form I, seven males, form II, three juvenile males, and one juvenile female) in the National Museum of Natural History, Smithsonian Institution.

Size. The largest first form male, the holotype, has a carapace length of 13.8 mm; the smallest, 8.0 mm.

Range. Known only from the type-locality.

Variations. All variations noted are minor ones, most associated with the degree of maturity of the specimens; none is so marked as to confuse this crayfish with any previously described species.

Relationships. *Procambarus milleri* has its closest affinities with *P. alleni* (Faxon, 1884; p. 110), one of the two epigean crayfishes known to occur in the southern part of the peninsula. The close relationship existing between the two is clearly demonstrated in the similarities between the first pleopods of the males. The long sinuous mesial process and the rounded, distally tapering shaft of the appendage constitute a combination of characters which exists in no other crayfishes. There can be no doubt that the two have had a common ancestry, and it is entirely possible, if not probable, that the troglobite was derived comparatively recently from a stock

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Figs. 16-19. Floridian troglobitic crayfishes. (Setae omitted from all structures illustrated except subterminal ones in 16-18b and 19a,b. Except for 18d and 19, see explanation for Figs. 12-15). Fig. 18d, mesial view of first pleopod of first form male. Fig. 19a, caudal view of third maxilliped of *T. maclanei*; Fig. 19b, caudal view of third maxilliped of *P. pallidus*; Fig. 19c-e, diagrams of basal podomeres of left pereiopods of male with ischia stippled; c, hook on ischium of third pereiopod; d, simple hooks on ischia of third and fourth pereiopods; e, bituberculate hooks on ischia of third and fourth pereiopods. "i" in 19a, b=ischium.

of *P. alleni* which found its way into the subterranean channels of the oolitic limestone of the southern part of the peninsula.

Despite the marked similarity between the two, *P. milleri* may be distinguished readily from *P. alleni* by its albinistic quality, the absence of marginal spines or tubercles on the rostrum, and the small size at which it attains sexual maturity. It may be distinguished from all other troglobitic crayfishes by the structure of the first pleopod of the male, the only one in which the mesial process is sinuous and directed distally.

Life History Notes. First form males were collected in February, March, and May. The holotype was collected on May 2, 1968 when it was in the first form. It was placed in an aquarium where it molted on October 22 to second form, increasing its carapace length only 0.4 mm. It molted again on November 25, returning to the first form, with an increase in carapace length of 1.2 mm. It died on March 17, 1969. These observations were made by Mr. Miller who preserved the exuvia. The latter are deposited with the holotype.

Second form males were obtained in January, February, March, July, and August. The only female that has been found is a juvenile taken on January 24, 1968.

KEY TO THE TROGLOBITIC CRAYFISHES OF FLORIDA

1 Third maxillipeds lacking teeth on opposable border of ischium (Fig. 19a) *Troglocambarus maclanei* Hobbs, 1942a, p. 345
(Caves from Citrus and Hernando to Alachua counties)

1′ Third maxillipeds with teeth on opposable border of ischium (Fig. 19b) 2

2 Males with hooks on ischia of third pereiopods only (Fig. 19c); first pleopod with two terminal elements bent at right angles to main shaft of appendage (Fig. 18b, d,f). Females with annulus ventralis fused to sternum immediately cephalic to it, never overhung (ventrally) by tuberculate processes from sternum (Fig. 18e) *Cambarus cryptodytes* Hobbs, 1941, p. 110
(Caves and well in Jackson County, Florida and Decatur County, Georgia)

2′ Males with hooks on ischia of third and fourth pereiopods (Fig. 19d,e); first pleopod with three or four terminal elements, never with all bent at right angles to main shaft of appendage (Figs. 12-16b-d,f). Females with distinct flexible membrane separating annulus ventralis from sternum immediately cephalic to it, or membrane obscured by multituberculate processes projecting caudally from sternum (Figs. 12-16e) 3

3 Eye with pigment spot (Figs. 14,16a) 4

3′ Eye without pigment (Figs. 12,13,15a) 5

4 Pigmented area of eye faceted; rostrum without marginal spines or tubercles.

Males with first pleopod bearing distally directed mesial process (Fig. 16b-d,f). Female unknown *Procambarus milleri*, new species (Well in Dade County)

4′ Pigmented area of eye lacking facets; rostrum with marginal spines or tubercles. Males with first pleopod bearing caudodistally directed mesial process (Fig. 14b-d,f). Females with cephalic margin of annulus ventralis gently rounded, and lacking longitudinal, cephalomedian trough (Fig. 14e) *Procambarus lucifugus alachua* (Hobbs, 1940, p. 402) (Caves and sinkholes in Alachua and Gilchrist counties)

5 Rostrum narrower at base than near midlength. Males with distal portion of first pleopod bent caudad at about 80 degrees and cephalic process directed at angle of approximately 70 degrees to main axis of appendage (Fig. 13b-d,f). Females with sternum immediately cephalic to annulus ventralis devoid of tubercles (Fig. 13e)

Procambarus lucifugus lucifugus (Hobbs, 1940, p. 398) (Caves from Citrus and Hernando counties northward to Marion County where it intergrades with *P. l. alachua*)

5′ Rostrum tapering from base. Males with distal portion of first pleopod straight or bent caudad no more than at 45 degree angle and cephalic process, if present, directed at angle of about 35 degrees to main axis of appendage (Figs. 12, 15b-d,f). Females with sternum immediately cephalic to annulus ventralis bearing tuberculate prominences sometimes overhanging (ventrally) cephalic portion of latter (Figs. 12,15e) 6

6 Males with hooks on ischia of third and fourth pereiopods bituberculate (Fig. 19e); first pleopod lacking subterminal setae and cephalic process, and mesial process directed distally, not reaching bases of other terminal elements (Fig. 12b-d,f). Females with annulus ventralis as long as, or longer than, broad and bearing shallow, longitudinal, cephalomedian trough (Fig. 12e) *Procambarus acherontis* (Lönnberg, 1895, p. 6) (Spring and well in Seminole County)

6′ Males with hooks on ischia of third and fourth pereiopods simple (Fig. 19d); first pleopod with subterminal setae and well developed cephalic process, and mesial process directed caudodistally, clearly reaching level of bases of other terminal elements (Fig. 15b-d,f). Females with annulus ventralis approximately one-half as long as broad and lacking cephalomedian trough (Fig. 15e)

Procambarus pallidus (Hobbs, 1940, p. 394) (Caves and sinkholes in Alachua, Columbia, Suwannee, Leon, and Wakulla counties. Specimens from the latter two are juveniles and are tentatively assigned to this species.)

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Rate of Water Transport by *Brachidontes exustus*

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It is well known that many lamellibranchs feed on particulate matter, finely dispersed detritus and micro-organisms suspended in the water. Water is pumped through the gills, and suspended material is filtered out and retained. Knowledge of the water transport capacity of the gills is, therefore, essential to an understanding of the quantitative feeding biology and growth of this type of lamellibranch. This investigation will experimentally determine the rate of particle clearance by *Brachidontes exustus* and also examine the effect of temperature on this rate.

Many determinations of water transport through the gills of mussels and oysters in particular, which are of commercial interest, have been made. Both direct and indirect methods of determination have been used. In the direct method the rate of water pumping is measured by the removal of suspended particulate matter from water passing through the gills. The indirect method measures the stream of water leaving the animal by chaneling it into some sort of monitoring device.

Fox et al. (1937) worked out a procedure of indirect measurement. They placed the mussels in suspensions of calcium carbonate and determined the reduction in calcium by doing calcium analyses at various time intervals. Jørgensen (1943, 1949, 1952, 1955, 1960, 1966) and Jørgensen and Goldberg (1953) have used suspensions of algae and colloidal graphite. In the indirect method the organism is put into a known volume of a suspension, and the decrease in concentration of this suspension per unit of time is measured. It is not possible to get a continuous record of pumping this way, and if only a percentage of the particles are retained on the filtering mechanism the rate of water transport measured will be only a percentage of the total amount of water transported. However, as Jørgensen (1949) points out, if the size of food particles in the water is of importance for their retention by the gills, the indirect method offers perhaps, more information directly concerning the feeding biology than does the direct method.

Galtsoff (1926) was the first to devise a direct method. He used a glass tube in the exhalent siphon and a glass rod between the

valves to prevent their closing. The water from the exhalent siphon was led into a collecting cylinder and measured. Many modifications of the direct method have followed, most of them involving the use of a rubber dam to isolate the water pumped. A recent method of this type combining the efforts of many earlier workers is that of Drinnan (1964). Hamwi and Haskins (1969) have developed a direct method that does not include the use of rubber cones, the use of which may upset the feeding response of the organism.

The function of the gill as a food retaining filter was postulated over 100 years ago, and is universally accepted today. However, the exact mechanism responsible for particle retention is still not agreed upon. Jørgensen (1966) believes that the latero-frontal cilia act as a sieve. The distance between the latero-frontal cilia in *Mytilus edulis* is about 3 microns. If graphite colloidal particles of 1-2 microns are retained Jørgensen then explains this with MacGinitie's theory. MacGinitie (1941) said the latero-frontal cilia were not important in particle retention. He observed a mucous sheet covering the gill during food intake and believes this mucus is the straining mechanism. Dral (1967) believes the latero-frontal cilia beat is co-ordinated to vary the efficiency of particle retention and that the latero-frontal cilia are sticky; that particles of any size, no matter how small, will stick upon touching a cilium.

While the exact morphological structures and physiological responses are not yet agreed upon, the porosities of various lamellibranch gills are dependent upon many factors (Jørgensen, 1966; Dral, 1967). Temperature, salinity, *p*H, oxygen level, density of the suspension, amount of nutrients present, the way the animals are handled, whether or not they are ovigerous, and condition and age of the experimental animals all effect the filtration efficiency. We should keep this in mind in interpreting any results reported.

MATERIALS AND METHODS

Brachidontes exustus collected from oyster beds near Panacea, Florida, were used in this investigation. They were brought to the laboratory and kept in an aquarium with fresh sea water. The aquarium was aerated and at a temperature of 22 C-23 C. The

amount of particulate matter in the water in which they were collected was determined to be 18.4 mg/liter.

Colloidal suspensions of Aquadag, with a particle size of 1-5 microns, and Prodag, with a particle size of 5-15 microns, were used. (Both preparations are manufactured by Acheson Colloids Corporation, Port Huron, Michigan.) The test solutions were prepared by mixing a measured amount of the suspensions in a small amount of distilled water and then adding this to sea water filtered through a 0.45 micron Millipore filter. One liter of suspension was prepared immediately before each test. Each test was carried out in two 600 ml beakers, with 500 ml of suspension in each. Both beakers were aerated continuously and the mussel or clump of mussels were in one beaker only, with the other beaker acting as a control.

The rate of clearance was determined by using a Beckman Model DB-G grating spectrophotometer set at a wavelength of 550 millimicrons, to measure the reduction in concentration of the suspended mixture by the absorbance technique. The spectrophotometer was set to read filtered sea water as 100 per cent transmission. Each suspension was read at the beginning of a test and then four hours later when the test was concluded. Tests were run for four hour periods because while Aquadag and Prodag agglutinate only slowly in fresh suspensions of sea water, they settle out rapidly as suspensions get older.

The data were then used in Jørgensen's (1949) formula to calculate the amount of water pumped per unit time. This formula is most clearly expressed as

$$m = \frac{(\log P_0 - \log P_t)M}{\log e \ t}$$

where m is the quantity of water cleared from particles per unit time, M is the quantity of water used in the experimental vessel, t is the time the experiment runs, P_0 and P_t the concentrations of suspension in the control and the experimental vessel respectively at time t.

The wet weight of the blotted, soft body parts was recorded. The liter/hour rate obtained from Jørgensen's formula was divided

by this, to relate the rate of water pumped to body weight. The final rates are expressed as liters/hour/gram.

Tests were run at 22 C±1 C and at 10 C±1 C.

Results

Comparing the results of the experiments done at 22 C±1 C we can see a slightly higher water transport rate shown when Prodag was the colloidal preparation (Table 1).

When the experiments were repeated at 10 C±1 C we also see a slightly higher water transport rate shown in the Prodag preparations (Table 2).

Discussion and Conclusions

A comparison of Table 1 and Table 2 seems to indicate that temperature change, at least in this range, is not an important factor

TABLE 1

The rate of water propulsion of *Brachidontes exustus* as a function of particle size at 22 C

Prodag concentration in mg/liter	Rate of water transport in liters/hr/gm	Aquadag concentration in mg/liter	Rate of water transport in liters/hr/gm
10	3.8	10	3.6
20	2.9	20	2.9
30	1.5*	30	1.2*
40	1.8*	40	1.5*

*Indicates results from naturally occurring clumps of six mussels each.

TABLE 2

The rate of water propulsion of *Brachidontes exustus* as a function of particle size at 10 C

Prodag concentration in mg/liter	Rate of water transport in liters/hr/gm	Aquadag concentration in mg/liter	Rate of water transport in liters/hr/gm
10	3.5	10	3.3
20	2.9	20	2.7
30	1.2*	30	1.2*
40	1.9*	40	1.7*

*Indicates results from naturally occurring clumps of six mussels each.

in the rate of water transport. This agrees with Loosanoff's (1958) work, in which he studied rates of water transport in oysters between 16 C and 28 C and noted no significant differences. Rao (1953) has reported, however, that there is a higher rate of pumping in mussels with an increase in temperature. In contrast to the mussels used in Rao's work, which all weighed over 1 gm, the mussels in this investigation were all very small, and ranged in blotted wet weight between 13 mg and 30 mg. Size may have some effect on the action of temperature in physiological performance.

Although lamellibranchs are extremely sensitive to environmental changes it has been shown that smaller ones seem less sensitive than larger ones. (Jørgensen, 1960) The mussels, which ranged from 6 mm to 1 cm in length, showed no ill effects when enclosed in relatively small vessels. When they were transferred from the aquarium to a beaker, in no case did it take longer than 10 minutes for them to have byssal threads out, siphons extended and valves open.

It is apparent from Table 1 and Table 2 that the rate of water transport is higher when the concentration of suspension is lower. Loosanoff and Tommers (1948) have shown similar results in *Crassostrea virginica.* It was determined that 18.4 mg/liter of particulate matter was in suspension in the water in which these mussels were collected and perhaps the higher suspension concentrations have a depressant effect on the rate of filtration.

The higher rate of water transport in every experiment run was in the Prodag suspension. Prodag has a higher percentage of large particles than Aquadag, and this indicates that these mussels retain larger particles more efficiently. The exact means of particle retention is not agreed upon, so no conclusion can be drawn from this.

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Pinfish and Rockcut Goby, Fishes New to the Bahamas

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During July, 1969, two specimens of the pinfish, *Lagodon rhomboides* (Linnaeus), and four of the rockcut goby, *Gobiosoma grosvenori* (Robins), were collected in mangrove swamps near Jewfish Cay (23°27′N, 75°56′W), Great Exuma, Bahamas. These findings represent extensions of the known ranges of these fishes. *L. rhomboides* is known from Bermuda and the eastern coast of North America from Cape Cod to Yucatan (Caldwell, 1957). Lee (1889) recorded it from the Bahamas, but this report was discounted by Caldwell (1957). *G. grosvenori* has been known previously from Jamaica, Venezuela, and southeastern Florida (Böhlke and Robins, 1968).

The fish were taken in tidal creeks among mangroves from a depth of about one meter. The specimens of *L. rhomboides* (Academy of Natural Sciences of Philadelphia no. 109798) are 82 mm and 84 mm in standard length; those of *G. grosvenori* (University of Michigan Museum of Zoology no. 189301) range from 18 mm to 22 mm. Identification of the pinfish was made by James E. Böhlke; that of the gobies was by Reeve M. Bailey and the author with verification by C. Richard Robins.

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Chemical Control of Pigeon Reproduction

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Recently there has been an increased effort to develop chemicals for use as embryocides or chemosterilants to control populations of various pest animals. The chemical "Ornitrol" (Ornitrol [SC-12937] 20, 25 Diazocholesterol Dihydrochloride), developed by G. D. Searle & Co., Chicago, is the first chemosterilant to be registered by the U. S. Department of Agriculture. This drug coated on whole kernel corn is now available for use in controlling feral pigeon populations.

Initial research on the effectiveness of Ornitrol was conducted by Elder (1964) who found that the drug was 100 per cent effective in inhibiting reproduction in pigeons for three months and 75 per cent effective from four to six months after treatment. Field trials were conducted in northern cities by Wofford and Elder (1967). Further field trials were conducted in Bangor, Maine, by Gramlich and Woulfe (undated). The current study involves field trials in three southern cities, all in Florida. Field work was begun in April, 1969 and will be continued until at least June, 1970. Therefore, this report is not final and does not reject final results of the experiment.

Techniques

To determine the effects of Ornitrol three cities in northern peninsular Florida were chosen as study areas. These cities were Jacksonville (population 201,000 for the year 1960), Ocala (population 14,700 for 1960) and St. Augustine (population 13,600 for 1960). Jacksonville and Ocala were designated treatment areas; St. Augustine was named as the control area.

In Jacksonville two sites were selected for treatment. One was the city-owned Water Works at 1000 N. Main Street, in downtown Jacksonville. The second site was located about 2.4 miles west, adjacent to a railroad yard. This site was the City Products Corporation Ice Plant. In Ocala, the site selected was the Seminole Mills feed plant, about 0.3 mile northeast of the downtown area.

The site chosen in St. Augustine was Keterlinus Junior High School, about 0.5 mile north of the downtown area.

Treated sites were prebaited for a period of 10 days to two weeks with whole kernel corn. After this, corn treated with Ornitrol at the rate of 0.1 per cent by weight was put out at each site for a period of 10 days. The total amount put out and consumed each day was recorded by weight. In each of the treated cities Ornitrol was administered three times, i.e. April and September, 1969, and again in March, 1970.

In September, 1969, the number of treatment sites in Jacksonville was increased from two to five. The number of treatment sites in Ocala was increased from one to three in February, 1970.

In order to monitor the effect of Ornitrol, trapping was conducted at each of the four sites immediately following the first treatment. Trapping continued for the duration of the experiment on the average of 2.2 times monthly at each site. The number of birds at each site was calculated by the Schnabel method of estimating populations.

Birds which were trapped and banded were grouped according to age in the following classes: (1) less than two months; (2) two to four months; (3) four to six months; and (4) greater than six months. For the purpose of this paper, the first three classes were grouped together and considered young birds while the remaining class of birds over six months was designated the adult class. In this manner, the ratio of young birds to total number of birds trapped was recorded.

In November adult males were weighed at four sites, Ocala, St. Augustine, Gainesville and at the Ice Plant in Jacksonville. Average weights were calculated for each city and compared to each other.

In addition to the field data, a cage study was conducted to determine the consumption of treated corn when it was the only food available for a ten-day period.

RESULTS

Bait Consumption. The amount of treated corn placed at each site was measured and the average consumption per bird was calculated based upon the population estimates (Table 1). Average consumption per bird was also calculated for the cage study.

TABLE 1

Consumption per bird of treated corn according to location, April 1969

Ice Plant	Water Works	Ocala	Caged Birds
5.0*	6.6	10.5	6.6

*Ounces for 10 day period.

Consumption varied from 5.0 ounces per bird at the Ice Plant in Jacksonville to 10.5 ounces at the feed mill in Ocala. There are three factors which might explain the differences in bait consumption between the various sites. First, average consumption was determined by dividing the total amount of treated corn consumed by the estimated number of birds. While the total amount of treated corn consumed can be accurately measured, the number of birds present can only be approximated. An error of reasonable size will drastically affect the estimate of per bird consumption. Secondly, the feeding habits of the birds can determine the amount of bait consumed. In Ocala, where the birds fed primarily at the feed mill, relatively high consumption levels would be expected. Birds at the Ice Plant in Jacksonville, however, which had been observed to feed at four primary sites, would be expected to have somewhat lower consumption levels at any one site. Finally, the size of individual birds would affect the average consumption level. For example, birds in Ocala, which were the largest in size, also had the highest bait consumption.

A comparison of consumption data by feral pigeons and caged birds showed that caged birds consumed an amount somewhere in the mid-range of values for feral pigeons. This would seem to indicate that intrinsic site factors determined per bird consumption, and, furthermore, that the consumption at all sites was satisfactory.

Jacksonville, Ice Plant Population. This site had the largest pigeon population of the four study sites. The original population calculated from data gathered in April, May and June of 1969 was estimated at 1220 birds (see Table 2). This population declined steadily and for January and February, 1970, was estimated at 530, a 57 per cent reduction in the number of birds originally present.

Movements of birds in Jacksonville show that there is a certain amount of intermixing between flocks. From data obtained at the Ice Plant it appears that this area is primarily a loafing place for

TABLE 2

Summary of trapping data, April 1969 to March 1970

Location	No. Banded	Total Captured	Recaptures	Total Populations Initial	Total Populations Final
Ice Plant	1228	1834	33.0	1220 (1023-1615)*	530 (518-667)
Water Works	301	928	67.5	220 (207-234)	170 (159-204)
Ocala	437	1082	59.7	420 (352-437)	180 (170-207)
St. Augustine	131	649	79.9	110 (103-122)	73 (69-73)

*Confidence limits at 95 per cent confidence level.

young birds and that after reaching four to six months of age they emigrate to other areas of the city. This is supported by the low frequency of recapture of marked birds (33 per cent) and also by the relatively large number of young in the population, which was 84.1 per cent at the start of the experiment and remained as high as 35.6 per cent at the conclusion of this phase of the experiment (Table 3).

Jacksonville, Water Works Population. This flock was estimated at 220 birds for the initial trapping period. This number was reduced to 170 for the period October, 1969 through February, 1970, a 23 per cent reduction.

Adults in this population appear to be fairly well confined to the general vicinity of the study site. There was a tendency for young birds to be more mobile, since 5.3 per cent of them (12 of the 224 young trapped) were later caught at the Ice Plant, a distance of 2.4 miles away. Recaptures averaged 67.5 per cent at this site and

TABLE 3

Percentages of young according to location and time of year

Period	Ice Plant	Water Works	Ocala	St. Augustine
Initial (April-May 1969)	84.1	71.8	47.1	58.2
Final (Jan.-Feb. 1970)	35.6	10.8	20.4	19.9

the percentages of young at the beginning and end of the trapping period were 71.8 per cent and 10.8 per cent, respectively.

Ocala. The number of birds at Ocala was estimated to be 420 for the period April and May of 1969. This population also decreased as evidenced by the estimated 180 birds present for the period October, 1969, through March, 1970. These values indicate a reduction of 57 per cent. There was also a reduction in the per cent young in the population from 47.1 per cent initially to 20.4 per cent for January to February, 1970. The recapture ratio at this site averaged 59.7 per cent.

The movements of the birds in this flock seem to be restricted to the area of the feed mill, their primary source of food, and to the downtown area, their primary roosting and nesting location.

St. Augustine Population. The flock located in St. Augustine showed a population of 110 birds for May through June, 1969. Although this was the control flock, it showed a 34 per cent reduction in population to 73 birds for the period October, 1969 through February, 1970.

These birds seem to be confined to an area within 0.5 mile of the School and the adjacent ball park. This fact was verified by several observations on a flock of pigeons located at the downtown park 0.5 mile to the south. These observations failed to reveal any marked birds from the Ketterlinus Junior High School at this site, although four birds caught and marked at the park were repeatedly observed in company with the 40 to 50 birds normally present at that location.

Weights of Adult Males. Weights of individual birds showed that the largest birds occurred in Ocala where the average weight was 399 grams (see Table 4). Jacksonville birds formed a middle class with an average weight of 372 grams while birds in Gainesville and St. Augustine averaged 359 and 357 grams respectively. These weights are considerably less than those given by Levi (1963) which range from 14 ounces (403 grams) to 30 ounces (864 grams) for various breeds of pigeons.

DISCUSSION

Ice Plant. The transitional nature of the flock located in this area makes it difficult to measure the effectiveness of Ornitrol in re-

TABLE 4

Comparison of weights of adult males in grams according to location

Ocala	Ice Plant	Gainesville	St. Augustine
399	372	359*	357*

*Not significantly different at 95 per cent confidence level.

ducing the population. Since 5.3 per cent of the young trapped at the Water Works were later caught at the Ice Plant it seems reasonable to assume that this area is a loafing place for young birds. Also the high percentage of young found in the area indicate an influx or immigration of young birds into the area. Of the first 800 birds trapped at the Ice Plant, four were later caught at the Water Works. This indicates a level of 0.5 per cent emigration from the Ice Plant to the Water Works, but does not necessarily mean that there is a net increase in the number of birds at the Ice Plant.

To be in a steady state, one would expect the number of birds traveling from the Water Works to the Ice Plant to equal the number of birds traveling in the opposite direction. However, the data show that for every bird leaving the Ice Plant three birds enter this study area. Although this would indicate that the Ice Plant flock should be increasing due to immigration while the Water Works should be decreasing due to emigration there is one set of circumstances which would give a steady state. The data indicate the majority of birds entering the Ice Plant are juveniles (less than three months old), while those leaving are adults or sub-adults (over five months old). This would give a steady state only if birds in the age class (three to five months old) in temporary residence at the Ice Plant had a mortality of 67 per cent. This means that out of three birds entering the area two of these birds would be expected to die before they reach five months of age. The remaining bird would leave the area when it reached five to six months of age. If this were the case then the two sites would be in a steady state or equilibrium.

The population data show that the Ice Plant flock has undergone a reduction of 57 per cent in population, 23 per cent greater than that obtained in St. Augustine, the control site. This greater reduction can be attributed at least in part to the effect of Ornitrol on this and the surrounding flocks which were treated.

Jacksonville, Water Works. Movements of this flock have already been discussed in relation to the Ice Plant. With the exception of the young birds, which were noted to emigrate to the Ice Plant, this population appears to be fairly stable. This theory is further supported by the high rate of recapture (67.5 per cent) which occurred at this site.

Population estimates for this site show a reduction of 23 per cent, from 220 birds to 170. While this value is similar to the control area in St. Augustine there are two possible explanations for this. One factor is the high percentage of adults in the population at the end of the experiment. This would indicate that a larger proportion of this population is in the age class which has a lower mortality. The second factor which might cause this low rate of decrease would be a net influx of adult and sub-adult birds from surrounding untreated flocks.

Once again it is difficult to measure the effect of Ornitrol on reproductive success. The low percentage of young at the end of the experiment (10.8 per cent) indicate that the drug is having at least some effect on reproduction in the area immediately around the Water Works.

Ocala. Results to date show that the population at this site has been reduced 57 per cent. This reduction is quite large and it appears that the 23 per cent reduction above that observed for the control flock in St. Augustine could well be due to the effect of Ornitrol.

St. Augustine. Although this was the control site it also showed a marked reduction in the proportion of young in the population and also in the total population itself (34 per cent). It appears that this is primarily a seasonal fluctuation. Further observation will determine if this is the case.

Weights of Adult Males. There are two possible explanations for weight differences observed in adult males. The first is that individual size is correlated with food supply. In St. Augustine and Gainesville birds depend primarily on natural seed for their food. This means that they have to search for every seed and food particle they consume and hence they are the smallest of the three groups. On the other hand, birds in Jacksonville, eat the same size food particle but their source is dispersed in four primary locations. The situation in Ocala is similar to Jacksonville except that in Ocala

there is only one major source of food and that is grain spillage from the feed mill. Thus, since these birds have to go to only one source for food they are even larger than the Jacksonville birds.

A second and perhaps more obvious explanation would be that the difference in weights is due to treatment of the flocks with Ornitrol. The most obvious possibility would be a simple increase in food supply per bird due to a decrease in the population caused by Ornitrol.

SUMMARY

To obtain effective control of feral pigeon flocks careful analysis of each local population is essential. In cities such as St. Augustine and Ocala, where there is one major flock or where the flocks are discrete, individual sites may be treated with success. In contrast, large metropolitan areas must receive treatment at all major feeding sites simultaneously if the program is to be effective.

Preliminary analysis of the data indicate that for southern cities, the first treatment should be given as early as December or January to inhibit reproduction before it starts its upward trend.

Although the St. Augustine flock underwent a 34 per cent reduction in population, the 57 per cent reduction at both Ocala and the Jacksonville Ice Plant are sufficiently greater to attribute a large part of the difference to the effect of Ornitrol. Furthermore, it seems reasonable to assume that the downward trend in St. Augustine is an annual fluctuation, and that by June, 1970, the control population will be back up to its original level of May, 1969. The major problem to date seems to be the fact that the first treatment was not given until April while it should have been administered as early as December, 1968, or January, 1969.

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Wofford, J. E., and W. H. Elder. 1967. Field trials of the chemosterilant SC-12937, in feral pigeon control. Jour. Wildl. Mgmt., vol. 31, no. 3, pp. 507-515.

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Avifauna of the Cayman Islands

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The three Cayman Islands (Grand Cayman, Little Cayman, Cayman Brac) are situated in the northwestern Caribbean Sea (Fig. 1). Grand Cayman, the largest island (20 miles long and 5 miles wide, or 71 square miles), is 180 miles south of Cuba and about the same distance northwest of Jamaica. Both Little Cayman (9 square miles) and Cayman Brac (13 square miles) measure about 12 by 1 miles, with Little Cayman being 60 miles northeast of Grand Cayman and Cayman Brac 5 miles east of Little Cayman. These limestone islands are projecting peaks of the submarine Cayman Ridge that continues toward Cuba and British Honduras (Doran, 1955; Richards, 1955). Just south of Grand Cayman is the 20,000 ft trench known as Bartlett Deep. Attesting to their remoteness is the number of well-marked species and subspecies described from these islands; these include birds, insects (H. K. Clench, 1964), reptiles (Grant, 1940), and mollusks (W. J. Clench, 1964). Their intermediate position in the northwestern Caribbean Sea makes them ideal stopping places for migratory birds.

The greater portion of Grand Cayman is less than 15 feet above sea level, although a ridge on its north side rises to 60 feet. Lagoons and mangrove or buttonwood swamps are common especially in the low, central sections and around North Sound. On limestone bluffs inland are cut-over forests of red birch (*Bursera simaruba*), cedar (*Cedrela odorata*), mahogany (*Swietenia mahagoni*), thatch palm (*Thrinax argentea*), and other trees (Swabey and Lewis, 1946). Thick scrub, or secondary vegetation, containing manchineel (*Hippomane manchinella*), mahogany seedlings, logwood (*Haematoxylon campechianum*), and maiden plum (*Comocladia dentata*), is common inland, with interspersed pastures of guinea grass (*Panicum maximum*) and Seymour grass (*Andropogon metusus*). Local, small plantations of cassava, banana, breadfruit, and papaya are not uncommon, especially around the scattered human settlements. Annual rainfall is about 65 inches, with a distinct dry season from November through April. Prevailing northerly winds at that time are noticeably desiccating to the vegetation.

The topography of Little Cayman is similar to that of Grand

Fig. 1. Map showing location of the Cayman Islands in the Caribbean Sea.

Cayman, but a sheer cliff of 140 feet is found on the east end of Cayman Brac. The vegetation of the smaller islands is similar to that of Grand Cayman, except for a reduction in acreage of swampland, lagoons, and inland ponds.

Although these islands were discovered and named by Columbus in 1503, nothing was published about their avifauna until 1886, when W. B. Richardson made a collection of birds on Grand Cayman for C. B. Cory. Subsequent collectors and observers on the islands include the following: 1887, C. H. Townsend (GC) (see

Ridgway, 1887). 1888, C. P. Streator (CB); C. J. Maynard (LC, CB). 1891, J. P. Moore (GC). 1892, D. J. Sweeting (GC). 1896, C. B. Taylor (GC). 1904, M. J. Nicoll and Lord Crawford (GC, LC); Sir Frederic Johnstone (GC); P. R. Lowe and Bowdler Sharpe (GC, LC, CB). 1907-8, P. R. Lowe (GC, LC). 1911, W. W. Brown (GC, LC, CB). 1912-1914, T. M. Savage English (GC, see English, 1912, 1916). 1929, A. K. Fisher and A. Wetmore (GC). 1930 and later, J. Bond (chiefly GC). 1938, C. B. Lewis (GC, LC, CB). 1956 and 1958, C. H. Blake (GC, LC, CB). 1961, A. Schwartz and party (GC, LC, GB). 1964, E. Kidd (GC) (see Kidd, 1965). 1965, 1966, 1967, 1969, 1970, 1971, D. W. Johnston (GC, CB, LC). 1969, E. J. Fisk (GC). 1969, 1970, Alexander Cruz (GC). 1969, Ronald Pulliam and party (GC, CB, LC). 1970, Donald W. Buden (GC, CB). 1971, J. C. Barlow and party (GC).

Major collections of birds from the islands include those of Richardson reported by C. B. Cory (1886a, b); many of these specimens are still at the Field Museum of Natural History in Chicago. W. W. Brown's specimens described by Bangs (1916) are mostly at the Museum of Comparative Zoology at Harvard University. The British Museum has many of the specimens taken by Nicoll, Lowe, and others about 1904-1908. Bond's specimens from the 1930's are chiefly at the Philadelphia Academy of Natural Sciences. The U. S. National Museum contains specimens collected by Fisher and Wetmore (1929). Albert Schwartz and his collaborators amassed a valuable collection in the fall of 1961. These specimens are now in the Albert Schwartz-Ronald F. Klinikowski collection at Miami, Florida (Schwartz and Klinikowski, 1963). Specimens taken by Donald W. Buden in 1970 are at Louisiana State University, and those taken by David W. Johnston are at the University of Florida. Scattered specimens are known to exist in various other collections throughout the United States and abroad.

Cory (1892, p. 127) noted that "the Cayman Islands have been very well explored"; he listed 55 species from the islands (30 breeding). Subsequently in 1911 Lowe reported 75 species (34 breeding). The current list includes 151 species, of which at least 42 presently breed there. From these figures it is apparent that the increase from 55 to 151 is due chiefly to the addition of migrants and to the number and frequency of field observations in the past two decades. Of greater significance is the increase of breeding

species, even with the loss of *Mimocichla ravida* and *Icterus leucopteryx* from Grand Cayman, because some breeding species are obviously recent immigrants. Among these are such conspicuous species as *Phaethon lepturus, Sula leucogaster, Hydranassa tricolor, Himantopus himantopus, Sterna albifrons, Zenaida asiatica,* and *Chordeiles minor.* Thus even in the relatively short time of 60-80 years, conspicuous changes in avian population dynamics have characterized these islands.

In his several papers dealing with origins of the West Indian avifauna, Bond (1934, 1942, 1948) alludes to the Cayman Islands, and pertinent distributional data on Cayman Island birds are found in his field guides (1936, 1947, 1961), his check-list (1956), and its supplements.

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BIRDS DESCRIBED AS NEW FROM THE CAYMAN ISLANDS

In this list, the original name is given first with the appropriate citation, followed by the currently recognized synonym chiefly according to Bond (1956 and supplements).

GRAND CAYMAN

Zenaida spadicea Cory, Auk, vol. 3, p. 498, 1886=*Z. aurita zenaida* (Bonaparte)

Columbigallina passerina insularis Ridgway, Proc. U. S. Nat. Mus., vol. 10, p. 574, 1887=*C. p. insularis* (Ridgway)

Engyptila collaris Cory, Auk, vol. 3, p. 498, 1886=*Leptotila jamaicensis collaris* (Cory)

Chrysotis caymanensis Cory, Auk, vol. 3, p. 497, 1886=*Amazona leucocephala caymanensis* (Cory)

Coccyzus minor caymanensis Cory, Cat. Birds Americas, part 13, no. 2, p. 337, 1919=*C. m. nesiotes* Cabanis and Heine

Colaptes gundlachi Cory, Auk, vol. 3, p. 498, 1886=*C. chrysocaulosus gundlachi* Cory=*C. auratus gundlachi* Cory according to Short (1965)

Centurus caymanensis Cory, Auk, vol. 3, p. 499, 1886=*C. superciliaris caymanensis* Cory

Pitangus caymanensis Nicoll, Ibis, vol. 4, ser. 8, p. 582, 1904=*Tyrannus caudifasciatus caymanensis* (Nicoll)

Myiarchus denigratus Cory, Auk, vol. 3, p. 500, 1886=*M. stolidus sagrae* (Gundlach)

Elaenia martinica caymanensis Berlepsch, Proc. IV Intern. Ornith. Congr., p. 394, 1907

Mimocichla ravida Cory, Auk, vol. 3, p. 499, 1886

Vireo alleni Cory, Auk, vol. 3, p. 500, 1886=*V. c. crassirostris* (Bryant)

Vireo *caymanensis* Cory, Auk, vol. 4, p. 7, 1887=*V. magister caymanensis* (Cory)

Certhiola sharpei Cory, Auk, vol. 3, p. 497, 1886=*Coereba flaveola sharpei* (Cory)

Dendroica auricapilla Ridgway, Proc. U. S. Nat. Mus., vol. 10, p. 572, 1887=*D. petechia eoa* (Gosse)

Dendroica vitellina Cory, Auk, vol. 3, p. 497, 1886

Spindalis salvini Cory, Auk, vol. 3, p. 499, 1886=*S. zena salvini* Cory

Quiscalus caymanensis Cory, Auk, vol. 3, p. 499, 1886=*Quiscalus niger caymanensis* Cory

Icterus bairdi Cory, Auk, vol. 3, p. 500, 1886=*I. leucopteryx bairdi* Cory

Melopyrrha taylori Hartert, Nov. Zool., vol. 3, no. 3, p. 257, 1896=*M. nigra taylori* Hartert

LITTLE CAYMAN

Sula coryi Maynard, Contrib. Sci. 1, No. 1, p. 40, April 1889=*S. s. sula* (Linnaeus)

Dendroica crawfordi Nicoll, Bull. Brit. Ornith, Club, vol. 14, p. 95, 1904=*D. vitellina crawfordi* Nicoll

CAYMAN BRAC

Amazona leucocephala hesterna Bangs, Bull. Mus. Comp. Zool., vol. 60, p. 308, 1916

Elaenia martinica complexa Berlepsch, Proc. IV. Intern, Ornith. Congr., p. 395, 1907=*E. m. caymanensis* Berlepsch

Mimocichla coryi Sharpe, in Seebohm, Monogr. Turdidae, vol. 2, p. 215, 1902=*M. plumbea coryi* Sharpe

Quiscalus jamaicensis bangsi Peters, Auk, vol. 38, p. 442, 1921=*Q. n. bangsi* (Peters)

Euetheia coryi Ridgway, Auk, vol. 15, p. 322, 1898=*Tiaris olivacea olivacea* (Linnaeus)

ANNOTATED LIST OF SPECIES

Nomenclature used here follows chiefly that of Bond (1956, 1961 and supplements). Trinomials are given only when the existence of critically examined specimens is known.

Podilymbus podiceps (Linnaeus). Pied-billed Grebe. GC, LC, uncommon to common resident on ponds, breeding; CB, one sight record, 27 June 1970 (DWJ). A specimen taken by Schwartz on GC was identified as *P. p. antillarum*, but *P. p. podiceps* might also occur in these islands.

Phaethon lepturus Daudin. White-tailed Tropicbird. Reported by English (1916) as common in waters around GC; CB, observed 4-5 May 1970 (DWB) and breeding commonly on bluffs (June 1970, DWJ).

Pelecanus occidentalis Linnaeus. Brown Pelican. GC, reported by English (1916) as "occasional at almost any season," and this statement applies currently for all three islands.

Sula leucogaster leucogaster (Boddaert). Brown Booby. CB, breeding commonly on bluffs (December 1969, RP; late June 1970, DWJ) and probably resident in nearby waters; observed 4-5 May 1970 (DWB).

Sula sula sula (Linnaeus). Red-footed Booby. LC, breeds (Nicoll, 1904; Lowe, 1911); CB, reported breeding by Cory (1889b) probably an error.

Phalacrocorax auritus (Lesson). Double-crested Cormorant. GC, a live bird was found on the beach at Spots (ESE Georgetown), 20 December 1970. It died overnight and was discarded (DWJ).

Anhinga anhinga (Linnaeus). Anhinga. LC, an adult male seen 5 August 1971 (DWJ).

Fregata magnificens Mathews. Magnificent Frigatebird. GC, CB, LC, occasional at any season. LC, breeds commonly on large lagoon along with *Sula sula*.

Ardea herodias Linnaeus. Great Blue Heron. GC, CB, uncommon in fall and winter (5 September-22 December), one spring record on GC (2 April 1970 DWB).

Butorides virescens maculatus (Boddaert). Green Heron. GC, CB, LC, common breeding resident, especially in mangrove swamps.

Florida caerulea (Linnaeus). Little Blue Heron. GC, uncommon resident, breeding (?); CB, LC, probably resident.

Ardeola ibis ibis (Linnaeus). Cattle Egret. GC, probably resident, breeding (?), first recorded in 1957 (Bond, fourth supplement); CB, LC, probably resident, uncommon perhaps due to small numbers of livestock.

Casmerodius albus (Linnaeus). Common Egret. GC, uncommon in win-

ter (October-12 May); CB, uncommon, single birds seen in June and October.

Egretta thula (Molina). Snowy Egret. GC, common resident, breeding (?); CB, uncommon, June and October-December; LC, common in August.

Hydranassa tricolor ruficollis (Gosse). Louisiana Heron. GC, common breeding resident; CB, May and June 1970; LC, common in summer.

Nycticorax nycticorax hoactli (Gmelin). Black-crowned Night Heron. GC, one specimen (1 December 1931, Bond, 1945).

Nyctanassa violacea (Linnaeus). Yellow-crowned Night Heron. Lowe (1911) described this form as resident in the Caymans; it is currently an uncommon breeding resident.

Ixobrychus exilis (Gmelin). Least Bittern. GC, one bird seen on inland marsh (15 March 1970, DWB).

Botaurus lentiginosus (Rackett). American Bittern. GC, one record, 28 January 1904 (Lowe, 1911).

Plegadis falcinellus (Linnaeus). Glossy Ibis. GC, one bird seen 17 December 1969 (DWJ and others); CB, two birds seen 26 June 1970 (DWJ) and recorded in early fall (Bond, twelfth supplement).

Eudocimus albus (Linnaeus). White Ibis. GC, four immatures seen during March 1970, one taken (DWB).

Ajaia ajaja (Linnaeus). Roseate Spoonbill. GC, one bird seen 11 August 1971 (DWJ).

Phoenicopterus ruber Linnaeus. Roseate Flamingo. CB, one bird reported by an island resident in October 1969; LC, one bird about October 1970.

Dendrocygna arborea (Linnaeus). West Indian Tree Duck. GC, LC, uncommon breeding resident; CB, 12 October 1956 (CHB).

Anas discors Linnaeus. Blue-winged Teal. GC, winter resident (9 September-late April); CB, LC, October (CHB).

Anas americana (Gmelin). American Widgeon. GC, uncommon (21 November-18 December 1969, EJF).

Spatula clypeata (Linnaeus). Northern Shoveler. GC, reported by hunters in winter.

Aythya affinis (Eyton). Lesser Scaup. GC, uncommon winter resident (16 December-March).

Oxyura dominica (Linnaeus). Masked Duck. GC, resident and breeding about 1916 (English) but present status uncertain.

Cathartes aura (Linnaeus). Turkey Vulture. GC, of questionable occurrence but believed seen by English (1916); CB, one bird on 25-26 June 1970 (DWJ).

Circus cyaneus (Linnaeus). Marsh Hawk. GC, uncommon winter visitor (21 November-28 December).

Pandion haliaetus (Linnaeus). Osprey. GC, CB, LC, uncommon at any season; no breeding evidence.

Falco columbarius Linnaeus. Pigeon Hawk. GC, occasional in winter, (16 December-12 April); LC, specimen 27 February 1905 (Lowe, 1911).

Falco sparverius Linnaeus. Sparrow Hawk. GC, uncommon in winter, October-April; CB, November-December 1969 (RP).

Porzana carolina (Linnaeus). Sora. GC, a road-kill near Boddentown, 20 December 1970 (DWJ).

Porphyrula martinica (Linnaeus). Purple Gallinule. GC, two birds 12 May 1965 (DWJ) and a specimen 17 August 1961 (AS).

Gallinula chloropus cerceris Bangs. Common Gallinule. GC, LC, resident, breeding, common; CB, 4-5 May 1970 (DWB), 27 June 1970 (DWJ), and 9 August 1971 (DWJ).

Fulica americana Gmelin. American Coot. GC, breeding resident and especially common in winter; CB, November-December 1969 (RP); LC, uncommon breeding resident.

Charadrius semipalmatus Bonaparte. Semipalmated Plover. GC, occasional in fall and winter (19 August-18 December); CB, summer (Cory, 1889a) and 6 birds on 9 August 1971 (DWJ). Lowe (1911) reported it as "resident in the Caymans."

Charadrius wilsonia Ord. Wilson's Plover. GC, uncommon in fall (November-December, EJF). Brown thought it to be breeding (Bangs, 1916). CB, one bird 9 August 1971 (DWJ).

Charadrius vociferus Linnaeus. Killdeer. GC, one individual observed 10 February 1970 (DWB).

Squatarola squatarola (Linnaeus). Black-bellied Plover. GC, uncommon winter resident (3 August-15 May); CB, 4 May 1970 (DWB), 10 on 9 August 1971 (DWJ) and October (CHB).

Arenaria interpres morinella (Linnaeus). Ruddy Turnstone. GC, uncommon winter resident (November-17 May); collected by Richardson during the summer (Cory 1886); CB, Cory (1889a) but no specific date, one individual observed 1 May 1970 (DWB), 20 on 8-9 August 1971 (DWJ); LC, one bird on 5-6 August 1971 (DWJ).

Himantopus himantopus (Müller). Black-necked Stilt. GC, breeding, less common in winter until early March; CB, LC, breeding, uncommon.

Capella gallinago Linnaeus. Common Snipe. GC, uncommon in winter (Lowe, 1911; November-8 April).

Actitis macularia (Linnaeus). Spotted Sandpiper. GC, fairly common winter resident (21 November-17 May), collected by Richardson in summer (Cory 1886); CB, 5 May 1970 (DWB) and 9 August 1971 (DWJ); LC, Cory (1889a) and 5-6 August 1971 (DWJ).

Tringa solitaria Wilson. Solitary Sandpiper. GC, uncommon in winter (3 August-mid April).

Tringa melanoleuca (Gmelin). Greater Yellowlegs. GC, uncommon to common winter resident (11 August-27 April); CB, October (CHB); LC, 4 on 5 August 1971 (DWJ).

Tringa flavipes (Gmelin). Lesser Yellowlegs. GC, uncommon to common winter visitor (7 September-April), collected by Richardson in summer (Cory 1886).

Catoptrophorus semipalmatus semipalmatus (Gmelin). Willet. GC, resident (less common in winter), breeding; CB, LC, uncommon, breeding.

Calidris canutus (Linnaeus). Knot. GC, two records, 18 December 1969 (DWJ and others) and 11 May 1970 (DWB).

Calidris melanotos (Vieillot). Pectoral Sandpiper. GC, rare in fall (Cory, 1886; 7 September 1961-AS); collected by Richardson in summer (Cory, 1886).

Calidris fuscicollis (Vieillot). White-rumped Sandpiper. GC, many seen (one taken) on inland pond 11 May 1970 (DWB).

Calidris minutilla (Vieillot). Least Sandpiper. GC, rare in spring (11 May 1970, DWB), summer (Cory, 1886) and fall (7 September 1961, AS).

Calidris pusilla (Linnaeus). Semipalmated Sandpiper. GC, rare in summer (Cory, 1886), common in spring (2 April-17 May); CB, 40 birds on 7 August 1971 (DWJ).

Crocethia alba (Pallas). Sanderling. GC, uncommon in fall (October-21 November) and spring (28 March-24 April).

Limnodromus griseus hendersoni (Gmelin). Short-billed Dowitcher. GC, uncommon in fall and winter (4 August-18 December).

Steganopus tricolor Vieillot. Wilson's Phalarope. GC, two seen on inland pond 11 May 1970 (DWB).

Larus argentatus Pontoppidan. Herring Gull. GC, accidental, October 1956 (CHB); CB (Bond, 1956).

Larus atricilla Linnaeus. Laughing Gull. GC, uncommon visitor at all seasons; CB, June 1970 (DWJ); LC, October 1956 (CHB).

Gelochelidon nilotica aranea (Wilson). Gull-billed Tern. GC, two specimens, 9 September 1961 (AS).

Sterna h. hirundo Linnaeus. Common Tern. GC, uncommon in winter (7 September-18 December).

Sterna anaethetus recognita Mathews. Bridled Tern. GC, four specimens (AS), 7-8 September 1961.

Sterna fuscata Linnaeus. Sooty Tern. GC, one specimen taken 3 April 1970 (DWB).

Sterna albifrons antillarum (Lesson). Least Tern. GC, CB, LC, uncommon, breeding, absent in winter.

Thalasseus maximus maximus (Boddaert). Royal Tern. GC, found offshore and along reefs throughout the year, nonbreeding; CB, LC, October 1956 (CHB).

Chlidonias niger surinamensis (Gmelin). Black Tern. GC, four specimens 7 September 1961 (AS).

Anous stolidus stolidus (Linnaeus). Noddy Tern. GC, one record, a specimen 26 July 1888 (Field Museum).

Columba leucocephala Linnaeus. White-crowned Pigeon. GC, CB, LC, common resident, especially in wooded areas.

Zenaida aurita zenaida (Bonaparte). Zenaida Dove. GC, CB, LC, uncommon resident.

Zenaida asiatica (Linnaeus). White-winged Dove. GC, common resident; evidently absent before about 1935; CB, not uncommon (22 August 1961, AS; late June 1970, DWJ); LC, uncommon 5-7 August 1971 (DWJ).

Columbina passerina insularis (Ridgway). Ground Dove. GC, CB, LC, common resident, especially along roads and open places.

Leptotila jamaicensis collaris (Cory). White-bellied Dove. GC, uncommon resident, restricted to wilder, wooded portions.

Amazona leucocephala Linnaeus. Cuban Parrot. GC, *A. l. caymanensis* (Cory), resident in wilder portions; CB, LC, *A. l. hesterna* Bangs, not uncommon in center of islands.

Coccyzus minor (Gmelin). Mangrove Cuckoo. GC, CB, LC, uncommon, especially in winter. Although *C. m. nesiotes* is supposedly the breeding form of the Cayman Islands (Bond, 1956), *C. m maynardi* has been taken there too (Lowe, 1911; Fisher and Wetmore, 1931).

Coccyzus americanus americanus (Linnaeus). Yellow-billed Cuckoo. GC, one record, October 1956 (CHB); LC, two specimens, 24 August 1961 (AS); CB, 5 May 1970 (DWB).

Crotophaga ani Linnaeus. Smooth-billed Ani. GC, LC, common resident in fields and roadsides; CB, uncommon resident.

Tyto alba furcata (Temminck). Barn Owl. GC, CB, LC, very uncommon resident, nesting and roosting in caves and hollow trees.

Chordeiles minor (Forster). Nighthawk. We follow the suggestion of Bond (1936) that *gundlachii* is the (uncommon) breeding form of the Cayman Islands. During migration, however, in April and May a number of observers have reported Nighthawks calling in the fashion of "typical" continental North American birds.

Chaetura pelagica (Linnaeus). Chimney Swift. GC, rare, sight records 10-12 May 1965 (DWJ); CB, early fall 1966 (Bond, twelfth supplement).

Archilochus colubris (Linnaeus). Ruby-throated Hummingbird. GC, hummingbirds, most likely of this species, have been reported occasionally by residents over the island.

Ceryle alcyon (Linnaeus). Belted Kingfisher. GC, uncommon winter visitor (November-9 April); CB, November-December 1969 (RP).

Colaptes auratus gundlachi Cory (see Short, 1965). Flicker. GC, fairly common resident, especially in mangrove swamps.

Centurus superciliaris caymanensis Cory. West Indian Red-bellied Woodpecker. GC, fairly common resident.

Sphyrapicus varius (Linnaeus). Yellow-bellied Sapsucker. GC, LC, uncommon winter visitor; CB, November-December 1969 (RP).

Tyrannus tyrannus (Linnaeus). Eastern Kingbird. GC, two specimens, 1-8 September 1961 (AS).

Tyrannus dominicensis dominicensis (Gmelin). Gray Kingbird. GC, CB, LC, fairly common summer resident, especially in urban situations.

Tyrannus caudifasciatus caymanensis (Nicoll). Loggerhead Kingbird. GC, CB, LC, fairly common resident, frequently in or near mangrove swamps.

Myiarchus stolidus sagrae. (Gundlach). Stolid Flycatcher. GC, fairly common resident in woodlands.

Contopus virens (Linnaeus). Wood Pewee. GC, one specimen, 18 October and sight record 25 October 1956 (CHB).

Empidonax minimus (Baird and Baird). Least Flycatcher. GC, one specimen, 10 March 1904 (Nicoll, 1904).

Elaenia martinica caymanensis Berlepsch. Caribbean Elaenia. GC, CB, LC, very common resident.

Progne subis subis. (Linnaeus). Purple Martin. GC, four birds taken 9 September 1961 (AS), 40 seen on 11 August 1971 (DWJ).

Progne dominicensis (Gmelin). Martin. GC, uncommon spring transient (7 April-15 May).

Riparia riparia (Linnaeus). Bank Swallow. GC, uncommon spring transient (26 March-16 May).

Stelgidopteryx ruficollis (Vieillot). Rough-winged Swallow. GC, uncommon in spring (3 March-26 April) and fall (20-30 October, CHB).

Hirundo rustica erythrogaster Boddaert. Barn Swallow. GC, very common spring (2 March-16 May) and fall (10 August-December) transient; CB, Cory, (1889a), 9 August 1971 (DWJ), and November-December 1969 (RP); LC, 5-7 August 1971 (DWJ).

Petrochelidon pyrrhonota (Vieillot). Cliff Swallow. GC, rare in spring (26 April 1967, DWJ).

Petrochelidon fulva (Vieillot). Cave Swallow. GC, uncommon in fall (11-30 October 1956, CHB).

Mimus polyglottos orpheus (Linnaeus). Mockingbird. GC, very common resident; CB, apparently became established about 1956 (Bond, third supplement), now common and widespread; LC, recorded by Michael Harvey in 1966 and now common.

Dumetella carolinensis (Linnaeus). Catbird. GC, fairly common winter resident (November-25 April); CB, Cory (1889a).

Mimocichla plumbea coryi Sharpe. Red-legged Thrush. GC, accidental (probably the same bird, 1964-1966; DWJ, 1969); CB, common resident.

Mimocichla ravida Cory. Grand Cayman Thrush. GC, believed to be extinct (DWJ, 1965, 1969), last recorded in 1938 by Bernard Lewis.

Catharus fuscescens (Stephens). Veery. GC., one seen 2 May 1970 (DWB).

Polioptila caerulea caerulea (Linnaeus). Blue-gray Gnatcatcher. GC, uncommon in winter, late summer (Cory 1886); LC (Cory 1889a).

Bombycilla cedrorum Vieillot. Cedar Waxwing. LC, specimen 29 April 1888 (Field Museum).

Vireo crassirostris crassirostris (Bryant). Thick-billed Vireo. GC, CB, LC, common resident especially in dense thickets.

Vireo griseus (Boddaert). White-eyed Vireo. GC, one seen 15 December 1969 (DWJ).

Vireo altiloquus (Vieillot). Black-whiskered Vireo. GC, two specimens, 27 March 1896 (Bond, eleventh supplement); CB, LC, *V. a. barbatulus* (Cabanis), uncommon resident.

Vireo magister caymanensis Cory. Yucatan Vireo. GC, common resident; CB, LC, reported by Cory, 1889a, but probably an error (see Hellmayr, 1935).

Mniotilta varia (Linnaeus). Black-and-white Warbler. GC, fairly common winter resident (late summer-12 May); CB, November-December 1969 (RP); LC, Lowe (1911).

Protonotaria citrea (Boddaert). Prothonotary Warbler. CB, 13 October 1956 (CHB); LC, specimen 24 August 1961 (AS).

Limnothlypis swainsonii (Audubon). Swainson's Warbler. GC, three birds seen 16-17 December 1969 (DWJ and others).

Helmitheros vermivorus (Gmelin). Worm-eating Warbler. GC, uncommon winter resident (October-31 March); CB, Cory (1889a).

Vermivora peregrina (Wilson). Tennessee Warbler. GC, three specimens, 16-18 April 1892 (Field Museum).

Parula americana (Linnaeus). Parula Warbler. GC, fairly common in winter (21 November-24 March); CB, Cory(1889a).

Dendroica petechia eoa (Gosse). Yellow Warbler. GC, CB, LC, very common resident especially in mangrove swamps.

Dendroica magnolia (Wilson). Magnolia Warbler. GC, rare, three records (18 December, 18 April, 12 May); CB, October (CHB) to December (RP).

Dendroica tigrina (Gmelin). Cape May Warbler. GC, uncommon winter resident (December-April); CB, November-December 1969 (RP).

Dendroica c. caerulescens (Gmelin). Black-throated Blue Warbler. GC, uncommon winter resident (16 December-11 May); CB, November-December 1969 (RP); LC, Cory (1889a).

Dendroica coronata (Linnaeus). Myrtle Warbler. GC, formerly common in winter (Nicoll, 1904), but not recorded in recent years; CB, November-December 1969 (RP).

Dendroica virens (Gmelin). Black-throated Green Warbler. GC, uncommon in winter (October-25 April).

Dendroica caerulea (Wilson). Cerulean Warbler. GC, rare, taken by W. B. Richardson in summer of 1886 (Cory, 1886); one taken 13 April 1970 (DWB).

Dendroica fusca (Müller). Blackburnian Warbler. GC, one specimen, 11 April 1892 (Field Museum).

Dendroica dominica dominica (Linnaeus). Yellow-throated Warbler. GC, uncommon winter visitor (late summer-29 December); CB, November-December 1969 (RP); LC, one specimen, 24 August 1961 (AS) and Cory (1889a).

Dendroica castanea (Wilson). Bay-breasted Warbler. GC, one seen October 1956 (CHB) and another on 2 May 1970 (DWB).

Dendroica breviunguis (Spix). Blackpoll Warbler. GC, two specimens, 20 September 1889 and 18 April 1892 (Field Museum); LC, one specimen, 24 August 1961 (AS).

Dendroica discolor discolor (Vieillot). Prairie Warbler. GC, uncommon fall and winter resident (16 August-3 March); CB Cory, 1889a; LC, Cory, 1889a, one specimen 24 August 1961 (AS).

Dendroica vitellina Cory. Vitelline Warbler. GC, fairly common resident (*D. v. vitellina*); CB, LC, common resident (*D. v. crawfordi* Nicoll).

Dendroica palmarum palmarum (Gmelin). Palm Warbler. GC, very common (in most years) winter resident (November-9 April); CB, LC, Cory (1889a).

Seiurus aurocapillus (Linnaeus). Ovenbird. GC, uncommon winter resident (16 December-6 April); CB, Cory, 1889a; LC, Lowe (1911).

Seiurus noveboracensis notabilis Ridgway. Northern Waterthrush. GC, uncommon winter resident in mangrove swamps (21 November-16 April); CB, Hellmayr, 1935.

Seiurus motacilla (Vieillot). Louisiana Waterthrush. GC, one specimen 4 August 1886 (Field Museum); CB, 6 December 1969 (RP) and one specimen 3 August 1888 (Field Museum).

Oporornis formosus (Wilson). Kentucky Warbler. GC, sight record, 17 December 1969 (DWJ).

Geothlypis trichas (Linnaeus). Common Yellowthroat. GC, common winter resident (21 November-14 May); CB, Hellmayr, 1935; LC, Cory (1889a).

Setophaga ruticilla (Linnaeus). Redstart. GC, fairly common winter resident (12 December-17 May); CB, Cory (1889a), November-December (RP) and 5 May 1970 (DWB); LC, one specimen, 24 August 1961 (AS).

Coereba flaveola sharpei (Cory). Bananaquit. GC, CB, LC, abundant resident.

Spindalis zena salvini Cory. Stripe-headed Tanager. GC, fairly common resident but uncommon in winter.

Piranga olivacea (Gmelin). Scarlet Tanager. GC, one observed 28 April 1970 (DWB); CB, one observed 4 May 1970 (DWB).

Piranga rubra (Linnaeus). Summer Tanager. GC, rare transient (late April, October).

Quiscalus niger (Boddaert). Greater Antillean Grackle. GC, common resident, especially in mangrove swamps (*Q. n. caymanensis* Cory); CB, LC, uncommon resident (*Q. n. bangsi* [Peters]). Curiously absent from CB in summers of 1970 and 1971.

Icterus galbula (Linnaeus). Baltimore Oriole. GC, male retained in captivity by Ira Thompson after it struck a window in Georgetown, 5 April 1971 (JCB).

Icterus leucopteryx bairdi Cory. Jamaican Oriole. GC, formerly (1900-1916) bred especially on north side of island, but not recorded since about 1938; probably extinct on GC.

Dolichonyx oryzivorus (Linnaeus). Bobolink. GC, fairly common spring transient (21 April-6 May); CB, several birds 5 May 1970 (DWB); LC, Cory (1889a).

Tiaris o. olivacea (Linnaeus). Yellow-faced Grassquit. GC, CB, LC, common resident, fields and roadsides.

Pheucticus ludovicianus (Linnaeus). Rose-breasted Grosbeak. GC, rare in winter and spring (22 December-10 April); CB, November-December 1969 (RP).

Guiraca caerulea (Linnaeus). Blue Grosbeak. GC, sight records, 2 April 1970 (DWB) and 21 October 1956 (CHB).

Passerina cyanea (Linnaeus). Indigo Bunting. GC, uncommon in winter and spring (17 December-10 May); CB, November-December 1969 (RP).

Melopyrrha nigra taylori Hartert. Cuban Bullfinch. GC, common resident in shrubby woods.

Passerculus sandwichensis savanna (Wilson). Savannah Sparrow. GC, rare, one specimen 10 March 1904 and sight record 18 December 1969 (DWJ).

Ammodramus savannarum (Gmelin). Grasshopper Sparrow. GC, fairly common in winter (November-4 April); CB, November-December 1969 (RP).

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Beaked Whales, *Ziphius cavirostris,* in the Bahamas

David K. Caldwell and Melba C. Caldwell

Published records of marine mammals from the Bahamas are scarce, especially those supported by specimens or photographs. Although often considered part of the West Indies, the main archipelago from which the following records come is very different ecologically. Not only does the main island group lie for the most part to the north and west of the Antilles, but the low islands are little more than exposed projections of the extensive reefs which form the vast shallows of the region rather than the high volcanic islands, rising abruptly from very deep water, which form the main Antillean chain. The Bahamian shallows are dissected by several deep channels such as Exuma Sound, Tongue of the Ocean, and the Providence Channels, and it is through one or more of these that our whales probably came. A good description of this area was presented by Böhlke and Chaplin (1968, p. xiii).

We know of no positive records for Cuvier's beaked whale, *Ziphius cavirostris* G. Cuvier, from the Bahamas, although it could be expected on zoogeographical grounds. The closest records are Florida (summarized by Layne, 1965, p. 138), Cuba (Aguayo, 1954), Isle of Pines (Varona, 1964) and Puerto Rico (Erdman, 1961, 1962; Moore, 1968, p. 234).

On 5 February 1968 members of a collecting crew from Marineland of Florida and Marineland of the Pacific were told of a dead whale that was ashore on Norman's Cay, one of the Exuma islands located on the western edge of Exuma Sound, some 40 miles SSE of Nassau at 24° 38′ N, 76° 48′ W. The crew was able to reach the badly decomposed carcass on the next day, and the animal proved to be a female measuring 16 feet from tip of upper jaw to fluke notch. Other measurements were taken, but the carcass was in such bad condition that in the interest of accurate reporting it seems advisable to omit them from the present report although they are on file at the Marineland Research Laboratory. The decomposed condition of the carcass caused some confusion as to its sex even on the part of the experienced observers. That it was indeed

a female was clarified later when one of the teeth was studied in light of Moore's (1968, p. 240) discussion of sexual dimorphism in the teeth of *Ziphius*. The narrow elongate shape of the tooth clearly indicated that it was from a female. The tips of the two teeth in place in the carcass were reported as just protruding from the gums at the tip of the lower jaw, but this protrusion probably was due to a shrinkage of the soft tissue during decomposition. The complete skull was salvaged about three weeks after the first report of the stranding, and it is presently being retained for further study at the Marineland Research Laboratory where in early 1970 Joseph C. Moore confirmed the sex as a female and noted the condylobasal length of the cranium to be 857 mm plus an estimated missing 40 mm of rostrum. Other measurements on this skull will be included in a variational study of *Ziphius* that Moore has in preparation.

At the same time that this whale was found, the collecting crew found another of about the same size elsewhere on Norman's Cay. The men were convinced that it was the same species as the first, and color photographs of the badly-decomposed carcass lying in the edge of the water bear this out. The photographs are on file at the Marineland Research Laboratory to support this record. Decomposition was so advanced that no measurements were attempted and the carcass washed out to sea before any skeletal material could be recovered. William Raulerson noted, however, that this animal was clearly the same species as the first, was of about the same size, and that the teeth were of the size, shape and degree of protrusion as the first animal and so the second, too, was probably a female.

On 7 February 1968 Cecil Walker observed yet another carcass, from the air from a low-flying spotter airplane, that was stranded on a small cay about 10 miles to the north of Norman's Cay. Walker noted that this carcass was about the size of the first two and that it appeared to be of the same species and in about the same state of decomposition. This carcass could not be reached for further study.

At about the same time as the first strandings, i.e., in early February 1968, the collecting crew was notified by Herman Wenzel that a 16-foot dead whale was ashore on his property at Staniel Cay, also in the Exumas on the western edge of Exuma Sound, some 40 miles SE of Norman's Cay. The crew was unable to investigate, but Mr. Wenzel later provided us with color photographs (also on deposit at the Marineland Research Laboratory) that confirm the

identification of the decomposed carcass as *Ziphius cavirostris.* We are unable to determine sex from the photographs. It was Mr. Wenzel's intent eventually to recover the skull for display at Staniel Cay.

More than chance seems to be involved in the finding of these four specimens, and while they were found scattered over a 40-mile stretch, the similar condition of the carcasses and their discovery at almost the same time in a relatively uninhabited area suggests that something like a mass stranding or other type of mass mortality had taken place somewhere else and the dead carcasses floated to their final points of discovery.

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For their efforts in seeking out strandings and in accumulating data we thank Cecil M. Walker, Jr., W. J. LeBlanc, William C. Raulerson and William A. Huck, all of Marineland of Florida, Frank J. Callandrino of Marineland of the Pacific, and Herman Wenzel of Staniel Cay and St. Louis, Missouri. Messrs. Raulerson, Walker, and LeBlanc should be especially congratulated for collecting the decomposing head.

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Socio-Physics: Should We Take It Seriously?

A. E. S. Green

As a physicist who served as an operations analyst with the Twentieth Air Force in the Pacific Theatre during World War II, I have wondered at the vastly increased mathematical complexity and statistical sophistication of present day Operations Analysis. Indeed I have had difficulty in reconciling this trend in the last quarter of a century with my personal experience. From a background as an experimental physicist, I found I could make helpful contributions to the solution of a considerable variety of problems that arose in combat during the 1944-45 era.

After 14 years of university work, I again became involved in operations analysis type problems in 1959 when, as a manager of a large industrial laboratory, I attempted to systematize the problem of salary determination. Just prior to this, I had worked extensively with the phenomenological independent particle model (IPM) of the nucleus (the shell and optical models). Fig. 1 shows neutron-nuclear IPM potentials according to these early IPM studies.

These curves represent an analytic potential, the Wood-Saxon potential. The dependence upon radial distanceis shown for various nuclei with the representative mass numbers indicated. With such potentials and modern electronic computational facilities, phenomenological physicists could, by solving the Schrödinger wave equation, account for the gross feature of a vast body of angular distribution data and energy level data (Green et al., 1968). The success of these phenomenological IPM studies has dictated the direction of purely theoretical approaches to the physics of the nucleus to this very day.

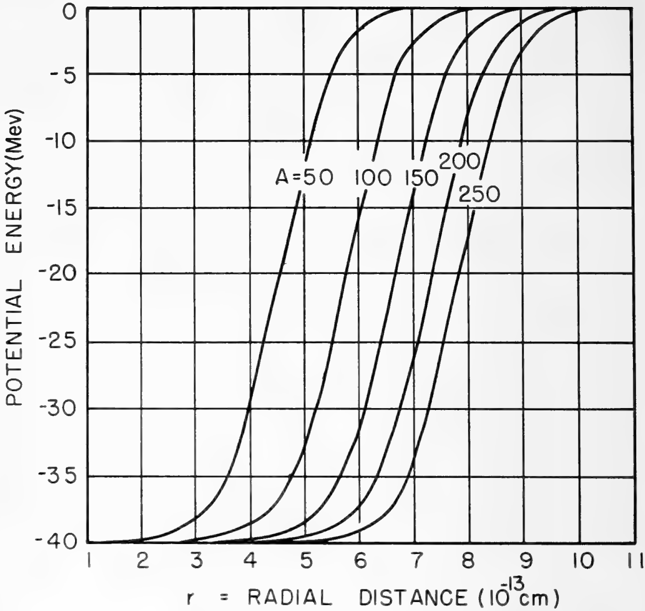

Fig. 1. Potential vs radial distance for neutrons interacting with nuclei whose mass numbers (A) are indicated.

SOCIO-PHYSICAL STUDIES

In the course of studying salary data for industrial scientists compiled by the Los Alamos Scientific Laboratory, I found it convenient to portray the data as shown in Fig. 2. The close resemblance of these curves in Fig. 1 suggested an analytic formula for the salary data (Green, 1962). In an updated version (Green, 1965) the analytic equation was generalized to represent a five-dimensional hypersurface r (z, A, σ, τ) where r is the rate of pay (analogous to radial distance), z is the percentile (potential), A is years since BS degree (mass number), τ a training factor which is 1/2 for PhD and $-1/2$ for BS or MS (isotopic spin) and σ is a supervisory factor which is 1/2 for supervisor and $-1/2$ for non-

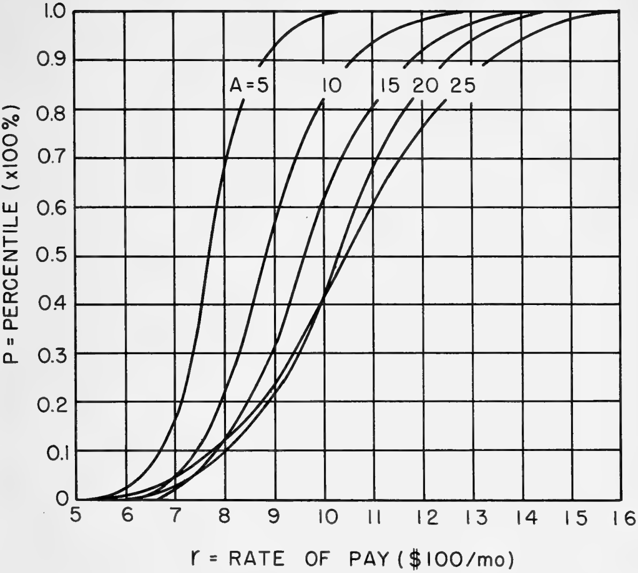

Fig. 2. Percentile vs. rate of pay for scientists whose years past BS degree (A) are indicated.

supervisor (spin). Figs. 3-4 illustrate the fit of the final equation in relation to experimental data and local least square fits.

The five dimensional hypersurface represented in analytic form proved to be a useful managerial instrument. It permitted group leaders to concentrate on the component elements which enter a salary decision and, among other things, to interpolate in a logical way between the extremes $\sigma = \pm 1/2$ when the scientist did only part time supervision. These component judgments made by several knowledgable men generally had very little scatter. This contrasted with the replies as to overall worth of the man which generally produced answers with much greater dispersion. Thus, the sociophysicists approach narrowed the range for judgment in decision and provided a useful guideline on salary questions which helped to avoid gross inequities. Tactically, it was also useful in argu-

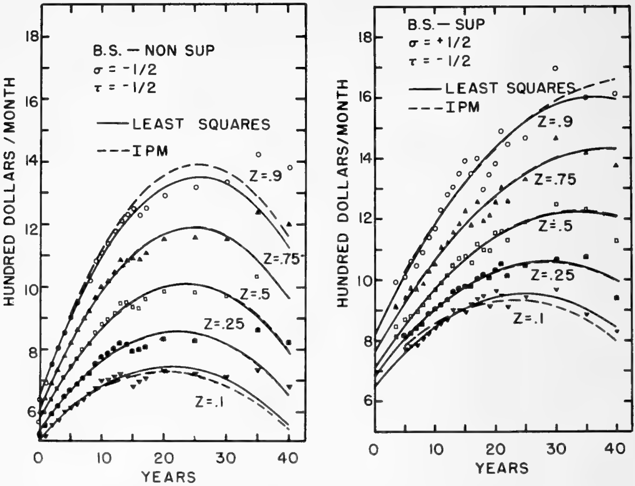

Fig. 3. Rate of pay vs years past BS for industrial scientists in 1962 for various percentiles. Solid curves give least square quadratic fits and dotted curves represent empirical equations. Notation in upper left indicates σ and τ values i.e., supervisory and training status.

ments for my personnel since I could speak with personnel managers from a position of authority (they had not published any papers on the subject).

A theoretical model emerging from the phenomenology indicated that Fermi-Dirac statistics might be operative in the free market place. Plausible explanations of how such a distribution might arise were given although this facet of the work was not pursued in great detail.

The socio-physics of the productivity of the scientist (Green, 1969) became a question of interest to me recently. Fig. 5 illustrates a productivity distribution taken from data presented by De Solla Price (1963). Curve 1 corresponds to an integral form of Lotka's law of productivity. Here the ordinate represents the number of authors who have published p or more papers and the abscissa represents the number of papers. Curves 2, 3, and 4 represent three relationships which more precisely fit the data. All of the equations were typical of physicist type equations and directly

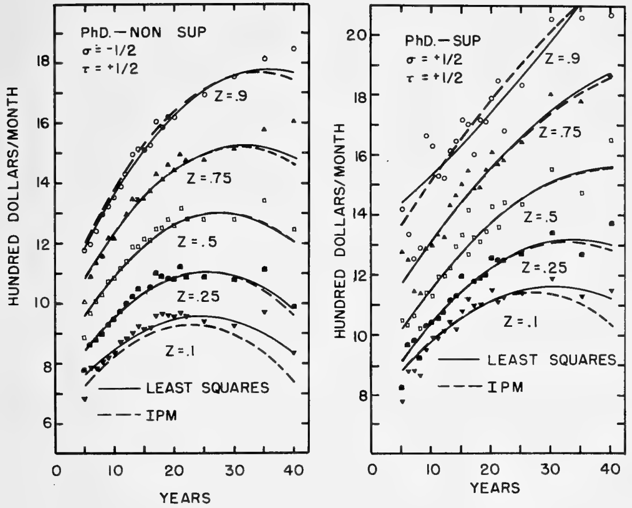

Fig. 4. Rate of pay vs years past Ph.D. for industrial scientists in 1962 for various percentiles. Curves and notations as in Fig. 3.

suggested models which could account for the data. Curve 3 corresponds to the Einstein-Bose formula suggesting that productivity follows boson statistics whereas we have already noted Fermi-Dirac statistics appear to govern reward. Curve 4 suggests a two population approach.

Our next illustration concerns socio-physical relationships stimulated by discussions at a conference on the Ombudsman. At this conference a major source of disagreement as to whether an ombudsman was needed at the local level was the broad meaning given to the word local. To some it meant a town with a population of say a thousand, whereas to others it meant cities such as Jacksonville, Atlanta, or Miami in the million persons category. Based upon data for the grievance officer staff at Savannah and Buffalo, I proposed a square root law relationship (Green, 1970) between ombudsmen (G) and population (P). Then in response to very pointed questions, I was able to establish a plausible justification for a $P^{1/2}$ law. Essentially if the civil servants (C) relate

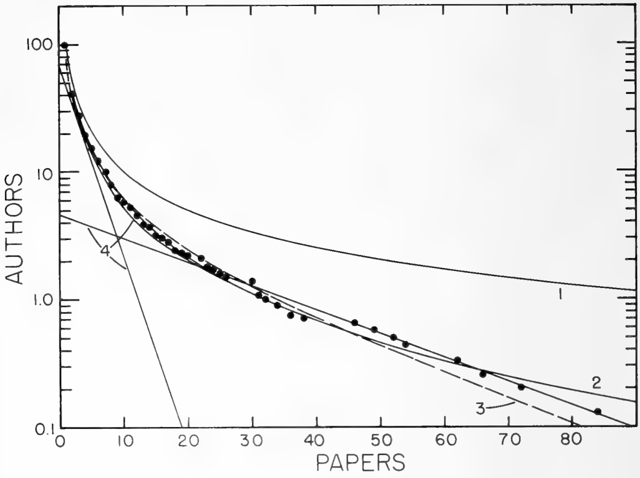

Fig. 5. Productivity Distribution. Curve 1 represents the integral form of Lotka's law (equation 1). Curves 2, 3 and 4 show the form of equations 2, 3, and 4 respectively. The two straight lines associated with line 4 (color) are the two exponential components; the curve, their sum. The dots represent experimental data from early volumes of the proceedings of the Royal Society, as compiled by Derek J. de Solla Price.

to population as $P\alpha$ and if ombudsmen relate to civil servants as $C\beta$ then $G/P\gamma$ where $\gamma=\alpha\beta$. If α and β were both less than 1 it is simple to rationalize $\gamma=1/2$.

After the conference, I found good data obtained from the Census Bureau to validate a power law relationship. Fig. 6 shows the state civil servants (in 1000's) per million in relation to the population. One sees with the exception of Hawaii (which can be explained) a distinct regularity $C/P\gamma P^{-1/4}$ which corresponds to $C\gamma P^{3/4}$. Subsequently, a substantial body of data on ombudsmen became available (Anderson, 1969) which is shown in relation to $P^{1/2}$ laws in Fig. 7. The final relationship should provide a helpful gross guideline for proposed legislation as to the personnel needed in ombudsman offices.

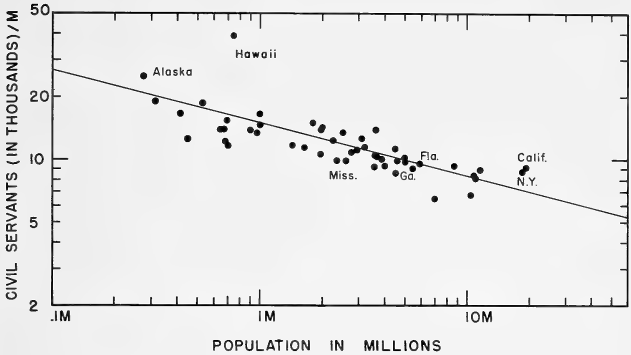

Fig. 6. The points (vertical scale) represent C/P for various states vs. P. The solid line corresponds C=KPα with α=3/4 and K_1=14,500.

Is Socio-Physics a Useful Discipline?

In connection with the last work the thought occurred to the writer and to others who heard of this work that perhaps there is a role that phenomenologically oriented physicists can play in quantitive studies of social problems. In preparing this talk for the Florida Academy of Sciences meeting on Science and Society, I have made a background literature search in which I learned that quantitive approaches in the field of sociology are developing very rapidly. A few recent sources which indicate that societal management using quantitive techniques is a coming field are agacs, 1970; Department of Health, Education and Welfare, 1969; Gross, 1965a, 1965b; Springer, 1970. Physicists could enter this field either by joining with the sociologist professionally or else by serving in conjunction with social scientists as quantitatively trained citizens to help guard against the potential abuse of societal type management. Phenomenologically oriented scientists, particularly those from fields such as nuclear physics or atomic physics where counting rates are high and the data is sharply defined, are especially prepared for sociological studies. Then the signal dominates the noise and it is not necessary to use sophisticated statistical techniques to unfold the signal from the noise. An analyst, with noise free data, can immediately concentrate on seeking regularities or

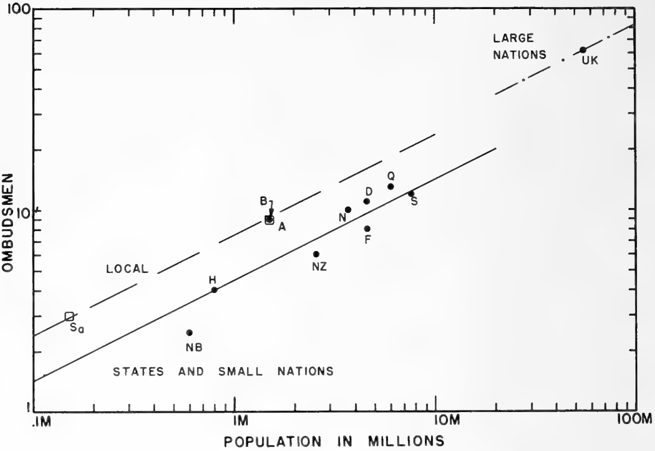

Fig. 7. The points represent ombudsmen (G) (including staff) vs. P. The solid line, a guideline for cities and other local governments, corresponds to $G = 7.5P^{1/2}$. Symbols are listed in Table 1.

phenomenological relationships in such data. The discovery of successful regularities should then set the stage for theoretical models and model testing.

This precise data, phenomenological regularity-theoretical model approach has been the path to almost all major discoveries in physics. As a classic example, we cite the observations of the positions of the planets by Brahe, the discovery of the three phenomenological laws of planetary motion by Kepler and the final theoretical explanation in terms of dynamics and the law of gravity by Newton.

It should be noted that, in the social sciences, very often the regularity itself can be used to solve managerial problems or to gauge trends or provide guidelines. Thus, in many practical sociotechnical studies, knowledge for its own sake is not entirely relevant. For such studies the phenomenological relationship itself might be the useful tool and it may not be necessary to go immediately to model building or a fundamental theoretical structure.

The Sociophysical approach contrasts with the methodology of Systems Analysis, Operations Analysis and Econometrics particu-

larly as they have developed since World War II. In scanning recent textbooks on these latter subjects, I have noted qualitative differences of approach in that books on econometrics and operations analysis rely heavily upon probability and statistics. Here the general approach is to first postulate a number of models in mathematical form and then to systematically test these models using statistical techniques. The object is to filter out the ones that fail so that we can confine ourselves to the fewer models which are not rejected. Because sophisticated statistics and probability theory are employed, experimental physicists coming from high counting rate fields might find the methodology used quite foreign. However, particle experimentalists, particularly those who have had to work with small numbers of counts and have had to develop their knowledge of statistical methods, might be comfortable in econometrics and operations analysis. System analysts, on the other hand, are very often required to make projections without the benefit of any data. Then, basically, one must invent system models and then apply tests of a hypothetical nature in an attempt to filter out the main inconsistencies in the model and to arrive at theoretical optimizations. Here, a particle theorist might play a useful role. One must note, however, that, as in particular theory, progress can be very slow and one must allow for the possibility that theoretical models might fail. In Econometrics and Operations Analysis in which statistical tests are frequently used, the experimental particle physicist certainly would bring to bear a good background and should be readily adaptable. In sociological problems, very often good statistics are available (census data, civil servant data, actuarial rates, crime rates etc.). Indeed the total historical count of basic units (persons living or dead) is about 10^{10} a goodly number even if cut in a great many ways. Here, the experimental nuclear physicist and other high counting rate physicists might readily bring his quantitative background to bear.

Conclusion

More important than the differences between types of physicists is the question of their acceptance by social scientists. One must, of course, take pains not to antagonize social scientists who have labored hard in their complicated field. In this latter connection, I have found that social scientists, who have been involved in

quantitative social legislative planning tend to welcome a quantitative outsider into their field. On the other hand, one must face up to the fact that many social scientists have observed the rise of importance of the physical scientist for twenty five years. Now that the turn for social scientist has begun, an invasion by physical scientists might not be welcomed. Furthermore, many social scientists have a distaste for quantitative approaches even by their compatriots. Thus, one must not anticipate that the transfer of a physical scientist to the social field will be a smooth one. Nevertheless, it is in the public interest to preserve the quantitative skills of the physical scientist and the social sciences now present an opportunity to make use of these skills in a constructive way. For this to be done professionally, the physicist must enter or join together with the social science community. Alternatively, the physicist may simply take an interest in the social science community and follow the trends of the managerial approaches to social science. Even if he does not become a sociologist, as a quantitatively trained citizen, he should be able to follow sociological trends, and ascertain that these trends are going in a direction towards fulfilling the needs of democracy. Thus, to "Socio-Physics, should we take it seriously?", we say yes.

SUMMARY

Recent developments of social indicators (Department of Health, Education, and Welfare, 1969; Springer, 1970; Agocs, 1970; Gross, 1965), reports and accounts are indicative of a strong movement towards a rationally managed social order. The grave nature of our environmental problems also points to a serious need for more comprehensive societal management. The instruments for societal management can, of course, be used to serve the priviledged or, as we hope, the many. In this article we describe an approach which broadens the pool of persons who may help solve societal management problems. We contrast this data-phenomenology-theoretical model approach with the theoretical model-statistical test approach of econometrics and operations analysis. The qualitative difference of attack suggests a need for a new interdisciplinary field, "socio-physics," which combines sociology with the methodology of physics.

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Mucoviscidosis Testing in a Community Hospital

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The importance of early diagnosis of mucoviscidosis (cystic fibrosis of the pancreas) is well stressed by the fact that one of every three individuals born with this condition dies during the first year of life (Schwachman, 1962).

From birth, these patients have an elevated concentration of chloride ions in their sweat. Measuring this elevation appears to be one of the best methods of diagnosis (Warwick and Hansen, 1965).

This report summarizes our experience with sweat chloride determinations following stimulation by pilocarpine iontophoresis and utilizing a Combination Chloride Electrode (Orion).

Materials and Methods

In general, we followed the same procedure as reported by Kopito and Schwachman (1969). All determinations were made at room temperature.

1. The chloride electrode is filled with a solution consisting of 1M KNO_3, 0.03M KC1 and saturated AgCl.
2. The meter is calibrated with standard solutions of 20 mEq Cl-per liter and 100 mEq Cl- per liter.
3. After calibration, the electrode is placed in a vertical position with the sensing crystal resting on several gauze pads moistened with ion free water.
4. A felt pad soaked with a 64 mg/100 ml pilocarpine-HCl solution is placed in the large slot of the iontophoresis attachment after excess saturant is removed.
5. A felt pad soaked with a 0.01M H_2SO_4 solution is placed in the small slot of the iontophoresis attachment after excess saturant is removed.
6. The assembly is strapped on the flexor surface of the forearm for five minutes while a current of one milliampere is delivered.
7. In newborns or infants, the assembly may be applied to the back instead of the forearm.

8. In children who complain of tingling or itching, the current may be reduced to 0.5 milliamperes for a short interval during the five minute period.
9. The assembly is removed and the test area is wiped with gauze moistened with distilled water and then blotted dry.
10. The electrode is blotted dry and immediately placed on the test area.
11. After the pointer stabilizes (10-15 seconds) a direct readout is made in milliequivalents of Cl- per liter.

RESULTS

We tested 118 individuals by this method. Our Cystic Fibrosis Clinic supplied the known afflicted patients. Most of their relatives were happy to cooperate also in the program. Patients with various ailments, mainly respiratory, were used as part of the control series. Healthy control individuals were picked at random from laboratory personnel and from their children.

DISCUSSION

As in most laboratory procedures, we found that individuals generally fell into three categories. One group represents those in which the results were clearly negative. In a second group, the results led to a diagnosis or high index of suspicion for the disease. The third group should be classed as borderline and here clinical follow-up and repeat testing are in order.

Several sources of error were found during the procedure, all of which were easily eliminated. No delay should occur in placing the electrode over the test area as the sweat evaporates rapidly (step #10). Excessive moistening of the skin area after sweat stimulation (step #9) should be avoided. Failure to remove excess saturant from the felt pads before placing them in the iontophoresis attachment slots (step #4 and step #5) was a source of error. Failure to control the restless patient would produce erroneous results.

We found that the five minute sweat stimulation period is optimum since no appreciable variation was noted when this period was prolonged to 10 or 15 minutes.

We have concluded that the Combination Chloride Electrode (Orion) provides a rapid (six minutes), harmless, and reliable screening method and aid in the diagnosis of mucoviscidosis that can be used on newborns, infants, children, and adults.

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Chemistry of the Sea

DEAN F. MARTIN

WE might well begin a consideration of the chemistry of the sea by recalling the words in Ecclesiastes. "All the rivers run into the sea, yet the sea does not overflow; unto the place from whence the rivers came, they return to flow again" (Eccl. 1:7). The writer of these words, if not familiar with the sea, was at least intuitively aware of the existence of a cyclic process that we recognize as being so very typical of the chemistry of the sea. His words suggest a basic question that we still are trying to answer and at this time we can give only a partial answer: What is the nature of the sea water, how did it come to be, and what are the consequences of the processes that brought it to its present state?

The nature of sea water is one of evident constancy, as indicated by three observations. First, a number of the major constituents of sea water (Table 1), i.e., those present in concentrations of 1 ppm or greater, show an evident constancy of composition. By this we mean that the weight ratio of, say, magnesium (or sodium or potassium) to chloride is constant for a given type of sea water. Second, the *p*H of sea water tends to be remarkably constant (8.1 ± 0.2)

TABLE 1

Major constituents of sea water

Constituent	Amount g/kg sea water
Water	
Chloride	19.353
Sodium	10.76
Sulfate	2.712
Magnesium	1.294
Calcium	0.413
Potassium	0.387
Bicarbonate	0.142
Bromide	0.067
Strontium	0.0080
Boron	0.0045
Fluoride	0.001

Average salinity, 35 parts per thousand (35 g of dissolved salts per kg of sea water).

at the mean temperature of sea water (5 C). Finally, many believe that the composition and pH of sea water has not altered significantly during the past 100 million years (Sillén, 1967a).

The geochemical balance is one approach that has been used to arrive at the rationalization of the present nature of the sea. This may be represented by a process first suggested by Goldschmidt nearly 40 years ago (Equation 1) (Sillén, 1967a).

(1) Igneous rock + Volatiles ⇄ Sea Water + Sediment + Atmosphere.

Goldschmidt assumed the process was unidirectional and that 0.6 kg of igneous rock reacted to produce each liter of sea water, together with 0.6 kg of sediment and 3 liters of atmosphere.

We would now modify Goldschmidt's approach in two ways. First, Horn and Adams (1966) were able to bring more elements (about 60) into geochemical balance by assuming that 1.2 kg of igneous rock and sediment were involved. Secondly, we would probably recognize that the reverse process occurs as an important feature of the cycle involved in sea-floor spreading. Neither of these changes would modify the conclusions arrived at by Goldschmidt's approach or Sillén's use of it to demonstrate the remarkable similarity between an equilibrium model of sea water and the properties of real sea water (Sillén, 1961).

Another difficulty arises. The geochemical balance may give us a good over-all view, but the subtleties or major physical-chemical processes are not immediately obvious.

The chemical and physical processes that control the present composition of sea water probably can be placed into several categories, for the sake of convenience. These include control by weathering, action of clays, crustal concentration, control by physical-chemical processes, and by organisms. The scope of this paper does not permit a thorough exploration of each of these, but examples can be given and reference made to more thorough treatments.

Weathering

The constancy of composition of sea water is astounding when we consider the effect of weathering, because the amounts of ions carried to the sea during the past 100 million years are enormous.

Weathering is the continued chemical interaction of rain with rocks and soil and is part of the cycle of interaction of sea and the earth's crust. The cycle consists of the evaporation of water from the sea, condensation as rain and snow, weathering, and chemical denudation of ions and suspended material via streams and rivers.

The extent of chemical denudation is uncertain because of the paucity of data for rivers of certain continents, notably Africa and Asia. The estimates of MacKenzie and Garrels (1966) have been used to calculate the amounts of ions added during the past 100 million years and to compare these with the present composition of sea water. (The units are moles of ion per square centimeter of earth surface, Table 2).

TABLE 2

Amount of dissolved ions added by rivers during 100 million years in comparison to present concentrations. (Sillen, 1967b)

	Cl^-	Na^+	SO_4^{2-}	Mg^{2+}	Ca^{2+}	K^+	CO_3^{2-}	NO_3^-
Added	157	196	84	122	268	42	342	11
Present Concentration*	150	129	8	13	2.8	2.7	0.3	0.01

*Concentrations are expressed in units of moles per cm^2 of total earth surface

Three features deserve comment. First, it is evident that the amounts of ions added generally are much greater than those now present. (Exceptions are sodium and chloride ions; probably, these ions represent sea spray washed back.) Second, the amounts of elements added during 100 million years is much greater than would be evident because of the contribution by suspended solids (250-640 kg per cm^2 per 100 million years). Third, the amount of non-volatile dissolved solids in the sea is slight relative to the amount of sediment. Sillén (1967b) has provided an apt comparison: the dissolved solids (as oxides) would cover the earth with a uniform layer 20 m thick, but the sediments layer would be thousands of meters thick, and the radius of the earth is about 6,400,000 m.

The last feature, the large amount of sediment and suspended solids, is very significant because these materials have a clay-mineral content. The control of composition by these minerals deserves more attention than it has received.

ACTION OF CLAY MINERALS

Clay minerals are important in the marine environment because of their ion-exchange capacity. This capacity may be represented by two typical processes (equations 2-3). Many believe that these equations are responsible for three significant roles of clay minerals: control of the *p*H of sea water, maintainence of the concentration of certain ions (sodium, magnesium, potassium), and control of the silica concentration (at least for certain concentrations).

$$\underset{\text{Illite}}{H^+ + KAl_3Si_3O_{10}(OH)_2 + 1.5H_2O} \rightleftarrows \underset{\text{Kaolinite}}{1.5Al_2Si_2O_5(OH)_4 + K^+} \quad (2)$$

$$\underset{\text{Na-montmorillonite}}{H^+ + 3Na_{.33}Al_{2.33}Si_{3.67}O_{10}(OH)_2 + 3.5H_2O} \rightleftarrows$$

$$\underset{\text{Kaolinite}}{3.5Al_2Si_2O_5(OH)_4} + 4SiO_2 + Na^+ \quad (3)$$

The significant features of the *p*H of sea water are (1) the apparent constancy (though changes occur in isolated bodies of water or because of biological activity), (2) the limited buffer capacity of an isolated 1-liter sample of sea water (0.003 mole of hydrochloric acid will reduce the *p*H from 8 to less than 4), (3) the buffer capacity of a liter of sea water in the ocean is great, perhaps 2000 times that for the isolated liter.

Sillén (1961) suggested that the major *p*H control mechanism in sea water is ion-exchange reactions (Equation 2) of clay minerals and that the carbonate system is mainly an indicator system. This is contrary to the view of many, but many arguments support Sillén's view (Martin, 1970). It appears that the time scale is an significant consideration. Pytkowicz (1967) believes that clay minerals have a significant effect in a geological time (ca. 1000 years) and that carbonate equilibra control *p*H in a shorter period of time.

Control of silica concentration by clay minerals (Eqn 3) appears to be a significant process, others being control by organisms and control by a physico-chemical process (the solubility of a hydroxylated magnesium silicate). Clay minerals typical of those suspended

in streams and brought to the sea, release silica and the two systems tend toward similar, intermediate values (Mackenzie et al., 1967).

Control of various ions by clay minerals involves equilibria of the type given (Equation 2) and is discussed elsewhere (Martin, 1970).

CRUSTAL CONCENTRATION

As Goldberg (1965) has noted, the concentration of an element in the marine environment may be low for two reasons: the concentration of the element in the source (crustal rocks or interior of earth) may be low or the element may be abundant in the source but its reactivity limits its concentration in sea water. Lithium is an example of the first condition, and aluminum is an example of the second.

The mean residence time, τ, is often used to correlate the relative reactivities of various elements in the marine environment. For a given element the value of τ is defined as the mean time the element is in sea water before removed by precipitation (Equation 4).

$$\tau = \frac{A}{(\mathrm{d}A \,/\, \mathrm{d}t)} \qquad (4)$$

Here, A is defined as the total amount of element suspended or dissolved in sea water, and $\mathrm{d}A/\mathrm{d}t$ is the amount precipitating or introduced in unit time.

Values of mean residence times (Table 3) seem to fall into three groups. The alkali and alkaline earth metals (except beryllium) have long residence times and low reactivities. (The decrease in residence time with increasing atomic number of the alkali metal ion is consistent with the known parallel increase in retention in clay minerals.) A second group of trace elements have intermediate values and some are elements found in ferromanganese nodules in the oceans (Mero, 1965). The third group is composed of elements that have low residence times because they enter the ocean as solid phases (as clay minerals, volcanic glass, etc.) and because of high reactivities. Elements in the third group have residence times that are less than mixing times and spatial and temporal variations in the concentrations are marked.

TABLE 3

Mean residence times of selected elements*

Category	Element	Mean Residence Time, Years
Long	Sodium	260 million
	Calcium	8 million
	Potassium	11 million
	Lithium	20 million
Medium	Barium	84,000
	Zinc	180,000
	Manganese	1,400
	Cobalt	18,000
Short	Aluminum	150
	Beryllium	100
	Iron	140
	Chromium	350

*From Goldberg (1965)

Control by Physical-chemical Processes

The upper concentration that a metallic ion or an anion might attain in sea water should be governed by the solubility of the least soluble compound. The importance of physical-chemical control by solubility probably has not received the attention it deserved, though excellent treatments of the subject are available (Goldberg, 1965; Krauskopf, 1956; Redfield, 1958, Sillén, 1961). Possibly, the major uncertainties in theoretical and experimental values of solubilities are responsible for the lack of attention. Nevertheless, three examples of the importance of control by solubility can be given here as an indication of the usefulness of the concept. Krauskopf (1956) calculated the theoretical maximum concentrations certain metallic elements would have, based upon the solubilities of compounds that might be formed with major anions of the sea. The results were compared with observed values that were obtained by adding the metal ion, as a solution, to sea water until a precipitate formed. The solids were not characterized, which may be a major fault of the experiment. The agreement between the two values is often close. But it appears that concentrations of many elements (lead, nickel, cobalt, copper, zinc, cadmium, and magnesium) are not controlled by solubility equilibria involving the major anions.

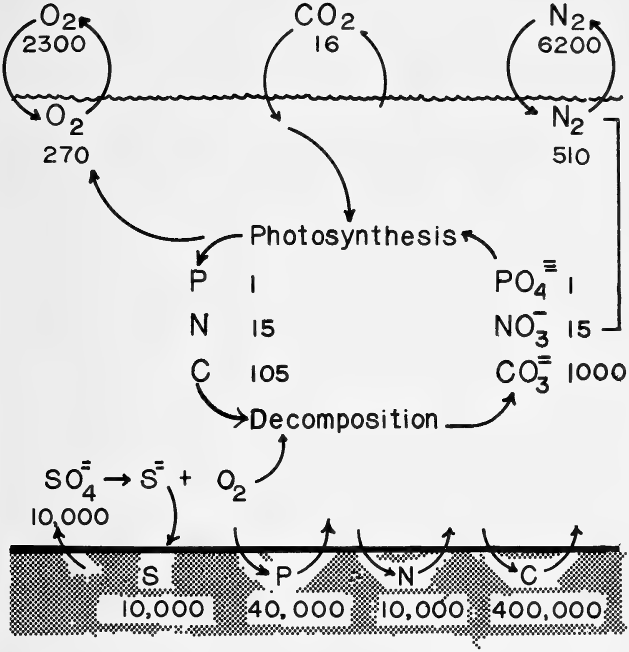

Fig. 1. Relative proportions and interaction of some major elements in the marine ecosystem. Ratios are based on the number atoms per atom of phosphorus in the sea (after Redfield, 1958; Martin, 1970).

The concentrations of calcium, strontium, and maybe barium do seem to be controlled by such equilibria.

The solubility of silica in sea water seems to be controlled to a major extent by the solubility of a hydroxylated magnesium silicate. The solubility of this material seems to limit the dissolved silica in real sea water to about 26 ppm (MacKenzie et al., 1967), though Siever (1962) indicated the concentration in brine or artificial sea water to be much greater (ca. 140 ppm).

Perhaps the control of phosphate is the most important example of physical-chemical control. Redfield (1958) has suggested that phosphorus is a master element, and this is evident from a consider-

ation of the relative number of atoms of each element in the sea, atmosphere, and earth's crust (Fig. 1). From a standpoint of atomic ratio alone, this seems to be an accurate view, though it does not imply that phosphate concentration limits the growth of these organisms and the question arises of what controls the concentration of the master element, phosphorus. The answer seems to be the solubility of a phosphate compound; which one is uncertain. Available data suggest that the order of solubility is $CaHPO_4 < Ca_3(PO_4)_2 < Ca_5(PO_4)_3OH < Ca_5(PO_4)_3F$. The last two compounds hydroxy and fluoroapatite probably are significant in control of phosphate concentration. Sillén (1961) estimates the phosphate concentration expected from the dissolution of hydroxyapatite is 10^{-7} M, which compares well with commonly observed values ($10^{-6} - 10^{-8}M$).

CONTROL BY ORGANISMS

Organisms control the concentrations of many elements in various domains of the sea, but two examples seem particularly appropriate for consideration: control of oxygen in the atmosphere and control of the nitrogen in the sea.

The balance of oxygen in the atmosphere is thought to be controlled by processes occurring in the sea (Redfield, 1958; Martin, 1970). Briefly, we assume the primodial atmosphere was devoid of oxygen and that the molecular oxygen in the present atmosphere is largely the result of a balance of five oxygen-producing and oxygen-consuming processes. These are (1) photochemical decomposition of water (Equation 5)

$$H_2O \xrightarrow{hv} H_2 + 1/2\ O_2 \qquad (5)$$

in which photons in the upper atmosphere effect decomposition with hydrogen escaping to outer space, (2) photosynthesis on land and in the sea basically leads to the production of bound organic carbon and oxygen (Equation 6); (3) biochemical oxidation

$$CO_2 \xrightarrow[\text{Chlorophyll}]{hv} C_{org} + O_2 \qquad (6)$$

(Equation 7) is effectively the reversal of the photosynthesis processes, (4) various oxidation processes (oxidation of sulfide and fer-

$$C_{org} \rightarrow O_2 + CO_2 \qquad (7)$$

rous minerals, oxidation of volcanic gases, industrial activity) remove oxygen from the atmosphere, (5) the action of sulfate-reducing bacteria (SRB) effectively provides oxygen, according to the overall process (Equation 8)

$$SO_4^{2-} \rightarrow S^{2-} + 2O_2 \qquad (8)$$

The relative importance of these processes has varied in geologic history. The first two processes (Equations 5,6) probably were the major oxygen-producing processes in the primitive world. Now, some believe that the major regulatory process is not photosynthesis involving phytoplankton because the combination of Equations 6 and 7 does not lead to a net production of oxygen. Photosynthesis produces a long-term net oxygen increase only to the extent that biological decomposition is avoided, e.g., through burial in an anoxic environment. Such environments are relatively rare on the surface of the earth, particularly in soil.

Redfield (1958) suggested that the action of sulfate-reducing bacteria might be responsible for the maintainance of the oxygen balance in the sea. The net process (Equation 8) actually consists of two steps. The first is production of bound organic carbon at the sea surface (Equation 6). The second involves utilization of dead organisms by sulfate-reducing bacteria (SRB) in an oxygen-poor environment (Eqn. 9)

$$C_{org} + SO_4^{2-} \xrightarrow{SRB} CO_2 + S^{2-} \qquad (9)$$

The existence of suitable environments in or near the world ocean is probably more extensive than generally believed and the importance of sulfate-reducing bacteria probably deserves more attention (Martin, 1970).

Organisms are involved in the nitrogen cycle of the sea in many

significant stages (Martin, 1970). Perhaps their most striking role is in resolving the evident imbalance in the nitrogen budget. We can summarize the consequences as described by Rittenberg (1963) and Sillén (1965) among others.

The second possibility, a missing entry, seems more reasonable, and it has been assumed to be denitrification, the biological reduction of nitrate (or nitrite) ion to nitrous oxide or molecular nitrogen. Denitrifying bacteria are known, for example, and they function in an oxygen-poor or anoxic environment.

The absence of suitable environments is a major difficulty in advancing denitrification as the missing entry in the nitrogen budget. For example, the estimated area and volume of appropriate sediments seems to account for only 10 per cent of the imbalance (Rittenberg, 1963).

Obviously, other localities must be involved. These are anoxic environments, (e.g., in the Black Sea, the Cariaco Trench, and certain Norwegian Fjords), intermittantly stagnant basins (e.g., the Gotland basin in the Central Baltic), and in the oxygen-minimum layers (Martin, 1970). The last possibility includes broad expanses of the tropical Indian and Pacific Oceans. Here, at about 150-800 meters, the dissolved oxygen concentration is very low. Goering (1968) has measured roles of denitrification in this layer by means of a ^{15}N-tracer technique. The layer is a site of active denitrification, but the extent of the process and the responsible organisms deserve more discussion and investigation (Martin, 1970).

SUMMARY

We have provided only partial answers to the questions raised initially. The apparent constancy of the sea is basically due to two causes. First the limitations of our analytical methods have not always allowed us to detect many subtleties that occur, though these limitations are becoming less restrictive. Second, the gross constancy of many properties may be ascribed to a marvelous balance that includes the few processes considered here. Control by weathering, action of clay minerals, crustal concentration, solubility limitations, and organisms is significant; the interrelationship between processes is far more significant.

TABLE 4

Nitrogen budget of the Sea*

Entry	Amount†
Reserve in Ocean	920,000
Annual use by phytoplankton	9,600
Annual contribution by:	
Rivers (dissolved N)	19
Rivers (suspended N)	0
Rain	59
Annual loss to sediments	9

*Rittenberg, 1963
†Units, million meter tons

The nitrogen budget of the sea (Table 4) appears to be unbalanced, i.e., the input from the land and atmosphere does not balance the nitrogen lost to the sediments (In contrast the phosphorus and silicon budgets appear to be balanced). The annual excess input is thought to be about 70 million meter tons (Table 4, Entry 3-4) if the ocean has attained a steady-state condition that we assume. Nitrogen must escape from the sea; otherwise, the annual loss of nitrogen to the sea should deplete atmospheric nitrogen in 400 million years (less than 20 per cent of the estimated age of the earth). Also, at the *p*H and *p*E (cf. Martn, 1970) of the ocean, molecular nitrogen should be irreversibly converted to nitrate ion (Sillén, 1965).

Two explanations of the imbalance are available, (1) the data are incorrect, or (2) an entry is missing.

The data in Table 4 have uncertainties, but there is no reason to believe they are erroneous and other estimates using different approaches yield a similar estimate (Martin, 1970).

Acknowledgment

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Leaf Shape Inheritance in Coleus

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Cultivated coleus (*Coleus blumei*) vary greatly in leaf shape as well as coloration. There are four major categories of variation in shape: deep versus shallow lobed margins, crinkly versus smooth, irregular versus regular, and narrow versus normal width.

A dominant gene (L) results in deep lobes, and also in complete male sterility. Another allele in this series results in deep lobes and male fertility (1^F), while a third allele (1) results in shallow lobes and male fertility (Rife, 1944).

A dominant gene (G) results in irregular leaves, a condition in which the leaf veins anastomose to form an oval area and the leaves tend to curl inward (Rife and Duber, 1946). Genes G and L interact to form very deeply lobed leaves, resembling those of watermelons. These genes are not linked.

Another dominant gene (C) results in a rough crinkly leaf surface, as opposed to the usual smooth flat surface (Rife, 1948).

The present report concerns the inheritance of narrow leaves, and relations between genes determining leaf width and other genes affecting leaf shape.

Materials and Methods

Seeds for narrow-leafed coleus were purchased from a commercial seed firm. They produced plants with leaves averaging 1/8-1/2 inches in width. They were vigorous and produced seeds within approximately three months.

Analysis of the inheritance of narrow leaves followed the usual procedure of obtaining F_2 and backcross ratios. The investigation also included tests for linkage and interactions of genes for narrow leaves with other genes affecting leaf shape.

Results

A plant from a pure breeding strain of narrow-leafed coleus was crossed with a normal leafed one from a pure breeding strain known as "Chartreuse". The F_1 progeny had narrow leaves. One of the F_1 plants was selfed and produced an F_2 ratio not deviating significantly from three with narrow to one with leaves of normal

TABLE 1

Results from crosses between narrow and normal (Chartreuse) varieties

Description	Observed		Expected		x^2	P
	Narrow	Normal	Narrow	Normal		
F_2	77	35	84	28	2.333	>0.10
Backcross	48	52	50	50	0.160	>0.50

TABLE 2

Chi-squared analysis of segregating progeny from selfed offspring of narrow × Purple cross to fit 13.3 ratio

Phenotypes	Observed	Expected
Normal	176	179.57
Narrow	45	41.53

$X^2 = 0.407$ $P > 0.50$

width. One of the F_1 plants was backcrossed to the Chartreuse parent resulting in an approximate 1:1 ratio of narrow versus normal-leafed offspring, thus indicating simple dominance of narrow leaves (Table 1).

F_2 progenies obtained from crosses of narrow-leafed plants with plants having irregular leaves and other plants having crinkly leaves gave ratios of approximately 9:3:3:1, indicating no linkage.

Quite different results were obtained from crossing a plant heterozygous for narrow leaves with one from a variety designated as Purple and having leaves of normal width. A total of 92 offspring was produced, all of which had leaves of normal width. Leaves of Purple were indistinguishable from those of Chartreuse in width. Sixteen of the 92 offspring were selfed, among which 7 produced both narrow and normal leafed offspring, in a ratio of approximately 13 normal to 3 narrow (Table 2). This is the expected ratio from selfing plants heterozygous for narrow, and also for a dominant inhibitor of narrow leaves. Presumably Purple carries the dominant inhibitor whereas Chartreuse does not. Mature narrow-leafed plants varied from some with extremely narrow leaves to others with leaves over 1/2 inch in width.

A plant heterozygous for narrow deep-lobed leaves was crossed with one having normal shallow-lobed leaves. Both plants were derived from Purple. Offspring occurred in a ratio not deviating

Fig. 1. Simply inherited variations in leaf shape. From left to right: normal, narrow, narrow irregular deep-lobed.

significantly from 3 normal shallow: 3 normal deep: 1 narrow shallow: 1 narrow deep. The greatest deviation was in the preponderance of narrow shallow over narrow deep, suggesting low viability of narrow deep-lobed plants. Otherwise the observed ratio conformed closely to the expected if the normal shallow-lobed parent was heterozygous for the dominant inhibitor (Table 3).

The narrow deep-lobed parent in the foregoing cross was later crossed with a normal shallow-lobed plant of the Chartreuse variety. Only 4 narrow deep-lobed plants occurred among 88 offspring,

TABLE 3

Test for 3:3:1:1 ratio segregation of Purple deep normal × Purple narrow

Phenotypes	Observed	Calculated
Normal shallow	44	37.75
Normal deep	39	37.75
Narrow shallow	14	12.25
Narrow deep	5	12.25

$X^2 = 6.310 \quad P > 0.10$

whereas the other three phenotypes occurred in approximately equal numbers (29 normal shallow, 27 normal deep, 28 narrow shallow). Here again low viability of narrow deep-lobed plants is indicated. Taking this into account the observed ratio conforms to the expected when neither parent carries a dominant inhibitor.

An independent investigation by K. Shepherd (1969, personal communication) gave similar results, with the exception that two dominant inhibitor loci appeared to be present in his normal-leafed variety. The ratios of normal to narrow-leafed plants in the original segregating progenies did not conform to the expected 13 normal: 3 narrow, thus ruling out a single dominant inhibitor locus. The ratios did conform to what would be expected from the complementary action of two dominant inhibitors.

SUMMARY

A dominant gene (N) is responsible for narrow leaves in coleus. A dominant inhibitor prevents its expression in one or more varieties, whereas the complementary action of inhibitors at two loci is indicated in another variety. No linkage is indicated between N and the genes responsible for deep lobes (L), irregular (G) and crinkly (C) leaves.

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Species, Class, and Phylum Diversity of Animals

David Nicol

If we divide the ecological realms into three major habitats (marine, fresh water, and land) and estimate the number of animal species living in each realm, we find that the land habitat has by far the greatest number of species. Taking Thorson's (1957, pp. 465-466) estimates in fractions for the three realms and converting them into whole numbers of species (Nicol, 1968, p. 37), we have the following figures: land 800,000, marine 166,667, and fresh water 33,333. This is based on an estimate by Thorson that there are about one million living species of animals. The overwhelmingly greater diversity of land animals is due to the arthropod class Insecta.

However, if we look at the diversity of animal classes and phyla in the three major ecological realms, the results are very different. I have used Blackwelder's *Classification of the animal kingdom* (1963) because of its completeness of all animal phyla and classes, including even extinct groups, and the fact that he lists the synonyms of the names of phyla and classes. This latter feature is most helpful when one is collecting ecological data from various invertebrate zoology books. Blackwelder lists 37 phyla of living animals and 86 classes of living animals. Some zoologists may believe that the number of phyla is somewhat excessive and that the number of classes is a bit conservative, but this should not greatly affect the final results. In Table 1 I have listed the 37 phyla and tabulated whether each one is found in the marine, fresh-water, or land realm. There are 34 phyla living in the marine realm, 17 in fresh water, and only 15 on land. If we carry this analysis to the class level, we find that 73 occur in the seas, 35 live in fresh water, and 33 live on land. If we add the phyla and classes of extinct animals listed by Blackwelder, 21 of these are found in marine strata, only one in fresh-water beds, and none in strata deposited on land.

A rather typical example of the distribution of a large phylum in the three major realms is the Mollusca. Of the seven living classes of molluscs, all live in the sea, only two have also invaded fresh water, and only one of these two (the gastropods) is also found on land. Of the estimated number of 107,000 living species of molluscs,

TABLE 1

The phyla of living animals with their distribution in marine, fresh-water, and land habitats

Phylum	Marine	Fresh water	Land
Protozoa	x	x	x
Porifera	x	x	
Mesozoa	x		
Monoblastozoa			x
Coelenterata	x	x	
Ctenophora	x		
Platyhelminthes	x	x	x
Rhynchocoela	x	x	x
Acanthocephala	x	x	x
Rotifera	x	x	x
Gastrotricha	x	x	
Kinorhyncha	x		
Priapuloidea	x		
Nematoda	x	x	x
Gordiacea	x	x	x
Calyssozoa	x	x	
Bryozoa	x	x	
Phoronida	x		
Brachiopoda	x		
Mollusca	x	x	x
Sipunculoidea	x		
Echiuroidea	x		
Myzostomida	x		
Annelida	x	x	x
Tardigrada	x	x	x
Pentastomida			x
Onychophora			x
Arthropoda	x	x	x
Chaetognatha	x		
Pogonophora	x		
Echinodermata	x		
Pterobranchia	x		
Enteropneusta	x		
Planctosphaeroidea	x		
Tunicata	x		
Cephalochordata	x		
Vertebrata	x	x	x
Totals 37	34	17	15

58,000 are marine, 14,000 are fresh water, and 35,000 are terrestrial (Nicol, 1969).

Much has been written recently on species diversity and the theories to attempt to explain diversity patterns, as for example, Hutchinson (1962), MacArthur (1965), Pianka (1966), and Valentine (1969). Some of the theories explaining species diversity and diversity patterns are contradictory, but some important factors for the great number of terrestrial species must be the greater range of the physical environment on land than in the seas and the complex and numerous relationships between insects and land plants, particularly the flowering plants.

On the other hand, little has been written on diversity patterns of the higher taxa, particularly the phyla and classes, and I believe that they must be considered in any attempt to explain diversity patterns. In a brief attempt to explain the greater diversity of phyla and classes in the seas, the fossil record is most enlightening. The basic differentiation of the animal phyla occurred in Late Precambrian, Cambrian, and Ordovician times, and to a lesser extent this is true of the animal classes (Nicol, Desborough, and Solliday, 1959). Most of this basic differentiation took place in the seas, not in fresh water or on land. Those relatively few major groups of animals that were able to invade fresh water and land, mainly in Silurian and Devonian times, have generally been highly successful in these habitats, and, furthermore, some of these classes have invaded the seas later, after they had become well established on land, as for example, the mammals, reptiles, and arachnids. Most of the basic differentiation of the animal kingdom, the appearance of phyla and classes, took place before animals invaded fresh water and land during Late Silurian and Devonian, and many of these marine groups never had the ability to invade fresh water or land because of physiological or anatomical deficiencies. Another telling point is the number of extinct phyla and classes of animals which are solely marine, and most of these became extinct before the close of the Paleozoic. This, then, may be the reason why we still find today that there is a much greater number of animal phyla and classes living in the seas rather than in fresh water or on the land.

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Recent Light Changes in Three Variable Radio Sources

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During the past decade astronomy has produced a series of surprises, not the least of which was the discovery of variable galaxies. As is often the case, it is difficult to see how this prominent phenomenon so long eluded detection. Quite probably the delay resulted because "common sense" seemed to dictate the impossibility of an object the size and luminosity of a galaxy changing its brightness significantly on a time scale short enough to be of interest to man.

A working catalog compiled by the writers now lists a total of 67 extra-galactic objects described in the literature as variable either in the optical region of the spectrum, in the radio region, or in both. A number of these objects are quasi-stellar radio sources ("quasars"), and the remainder are galaxies. Almost without exception the galaxies are of the "compact" type, with the bright, almost stellar nuclei that categorize them as Seyfert galaxies or N galaxies. There is now strong suspicion that quasars, N galaxies, Seyfert galaxies, and normal galaxies form an evolutionary sequence in descending order of violent, explosive activity in their nuclear regions. Low (1970) has suggested that galactic nuclei are composed of multitudes of cells ("irtrons") in which matter and antimatter are continuously being created. In this model the mutual annihilation of matter and antimatter generates the powerful infrared emission characteristic of the nuclei. Since irtrons steadily accumulate matter, they may become internally unstable and explode, or they may be disrupted by collisions with each other or with stars; it is these explosions, according to Low, that produce temporary flares in the light and radio flux received from the galaxy. The model pictures quasars as young protogalaxies, rich in irtrons and consequently highly unstable. In old galaxies such as our own, most of the irtrons have exploded, with the ejected matter forming the spiral arms and leaving the nucleus (hopefully) rather stable. The N galaxies and Seyferts, then, represent intermediate stages in this evolutionary sequence.

Since observations of the changes in these objects are obviously of prime importance in supporting or rejecting the numerous competing models such as Low's, a program of regular monitoring of a

Fig. 1. Observer at the Newtonian focus of the 30-inch reflector. The photographic equipment (camera, offset guiding microscope, and small finder) can be mounted at any of four observing stations spaced around the ring beam at the top of the tube.

large number of extra-galactic objects was inaugurated in 1968 at the University of Florida's Rosemary Hill Observatory. A limited number of the objects on the observing list had previously been shown to be variable by other workers, while a much larger number were selected because of a peculiar radio spectrum or other suspicious characteristic. The present paper details the observational results for three of the most interesting objects in the first category.

METHOD OF OBSERVATION

The principal instrument in the program is the 30-inch reflector shown in Fig. 1. Although the telescope is equipped with a photoelectric photometer at the Cassegrain focus, this system is not useful for objects fainter than 9th magnitude (9.0^m). Since most of the extragalactic objects of interest are in the range from the 16th-20th magnitude, it was immediately obvious that the work would have to be done photographically. A further decision was made to design the camera for the Newtonian focus to avoid having to remove and replace the massive Cassegrain photometer for each observing run.

A 2-inch field covering 1° in the sky is photographed on a 4 $\times$ 5-inch plate, which can be moved between exposures to record two such fields on each plate. Because of the coma intrinsic in large reflectors, only the central half of the field is of photometric quality. Normally, fast blue-sensitive Eastman 103a-0 plates are used, with exposures of 15 minutes reaching a limit of 19.5^m-20.5^m. The plates are processed in the new MWP-2 developer described by Difley (1968), which gives a significant gain in plate speed.

Standard procedure is to establish a magnitude sequence of comparison stars in each unknown field by photographing the field and the nearest of the 139 Mt. Wilson Selected Areas on the same plate, with identical exposures. The known magnitudes of stars in the Selected Area (Brun, 1957) are then transferred to the unknown field with the aid of an Astro Mechanics Cuffey iris astrophotometer. Checks of internal consistency indicate that relative magnitudes determined in this manner are probably reliable to $\pm 0.1^m$, although larger zero-point errors may exist, in part resulting from uncertainties in Brun's scales. In a few cases, well-calibrated star clusters have been employed in place of the Selected Areas. The magni-

tudes derived from the unfiltered blue-sensitive plates are, of course, photographic magnitudes, m^{pg}.

RADIO SOURCE 3C 120

The radio source 3C 120 (also catalogued as PKS 0430+05 and 4C 05.30) has been identified with an optical galaxy of the Seyfert type listed by Zwicky as IIZw 0430+05. Seyfert galaxies are bluish spiral galaxies distinguished by tiny brilliant star-like nuclei and spectra displaying strong emission lines that are often greatly broadened, suggesting violent internal motions; only 1 or 2 per cent of the spirals are of this type. Another important characteristic of the Seyferts is their powerful infrared emission. The total (bolometric) luminosity of the weaker Seyferts is comparable to the brightest of the normal galaxies, but 3C 120, the most luminous of the Seyferts, outshines many of the quasars. According to Low (1970), 3C 120 has an infrared luminosity of over 10^{46} ergs/sec, exceeding the nucleus of our own galaxy by five orders of magnitude

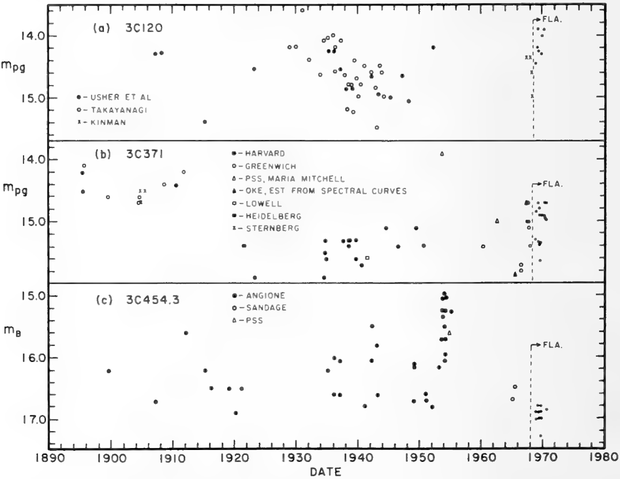


Fig. 2. Long-term light curves of 3C 120, 3C 371, and 3C 454.3. The sources of information are discussed in the text. In each case the University of Florida observations are shown to the right of the vertical dashed line.

and making it one of the most luminous objects known in the Universe. Kinman (1967) reports a red shift of z=0.0343, corresponding to a distance of about 100 Mpc.

It was not until 1968 that 3C 120 was reported as an optical variable (Kinman, 1968; Usher et al., 1969; Takayanagi, 1968). The work of Usher et al. and Takayanagi was essentially historical, making use of Harvard "patrol" plates of that region of the sky made in earlier years for other purposes. In this manner the observations were pushed back as far as 1906, although obviously with varying degrees of reliability. Also in 1968, Penston (1968) showed that 3C 120 was in fact identical with the variable "star" BW Tau discovered by Hanley and Shapley in 1940 and at that time erroneously classified an ordinary irregular variable star.

In Fig. 2a the data of Usher et al., Takayanagi, and Kinman have been combined in an effort to define long-term trends. The Usher points represent both single observations and those authors' averages of groups of observations closely spaced in time. In the case of the Takayanagi and Kinman data, the present writers have similarly averaged groups of data points to present the observations on the compressed time scale of Fig. 2. Such averaging may of course conceal short-term changes, but particularly in the earlier

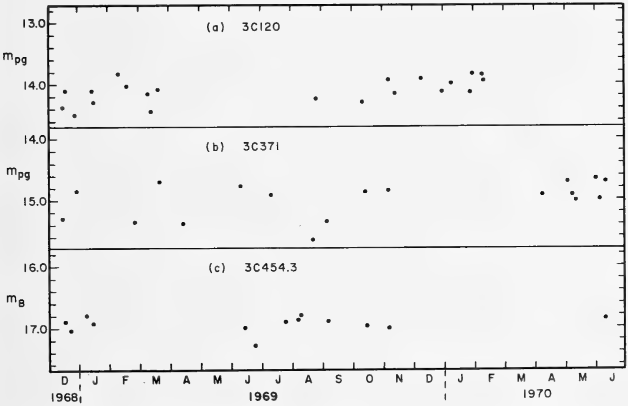


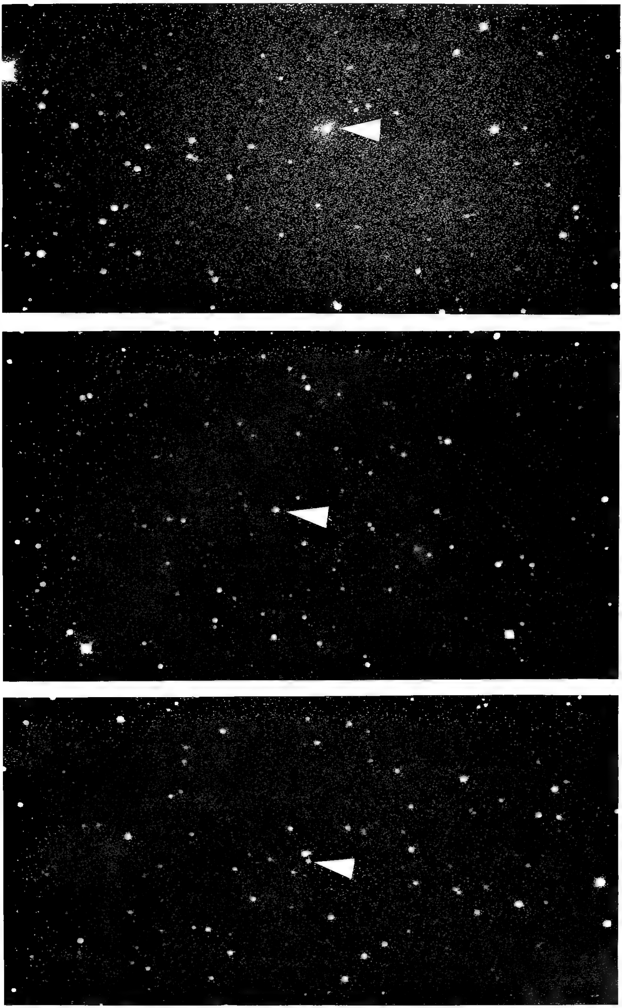
Fig. 3. University of Florida observations of 3C 120, 3C 371, and 3C 454.3. The recent observations, 1968-1970, are shown here in expanded form to display the short-term fluctuations.

data it is difficult to decide whether such fluctuations are real or merely represent errors in the observations. The most conspicuous trend is a steady decline in brightness from about 14.0^m to 15.0^m during the period 1930-1945. Usher et al. call attention to this trend and suggest that it is part of a 30-year cyclic variation, a conclusion that may place undue weight on a few early observations of dubious precision. The most recent published observations (Kinman, 1968) show a sharp decline in late 1967 and early 1968, from 14.8^m to 15.4^m.

As Fig. 3a indicates, the Florida observations begin in December of 1968 and continue into 1970. Fig. 4a is a print of 3C 120 and the surrounding field from a typical plate. The data suggest an increase from around 14.5^m to 14.0^m in late 1968 and early 1969, followed by a decline in the spring of 1969. There did not seem to be any significant change during the summer months, when 3C 120 was too close to the sun to be observed. A brightening of perhaps 0.4^m occurred during the [illegible] of 1969, followed by a period of small fluctuations about an average of 14.0^m until the object again disappeared into the evening twilight. In the reduction of the Florida plates we initially used the sequence of comparison stars published by Takayanagi (1968). However, on January 7 and 8, 1970, we made an independent calibration, using Selected Area 96; reductions based on this calibration show considerably less scatter than those depending on Takayanagi's work, and the magnitudes of our comparison stars are in good agreement with the B magnitudes published by Kinman (1968).

The Florida observations are included in compressed scale at the far right of Fig. 2a. Again, averaging of groups of points has been resorted to in order to show the data on this scale. Unless there are errors in the zero-points of the two scales, it would appear that 3C 120 brightened very rapidly by 1.5^m during 1968 and early 1969, perhaps the most precipitous rise in the 63-year run of data.

It is well established that 3C 120 is also variable in the radio region, at wavelengths from 2-40 cm (Kellerman and Pauliny-Toth, 1968; Pauliny-Toth and Kellerman, 1968). During the period 1966-1968, two violent radio outbursts were observed, first at short wavelengths and then at progressively longer wavelengths. In terms of the class of models proposed by Low (1970), 3C 120 appears to be



(a)

(b)

(c)

Fig. 4. The sources and their surrounding star fields. a) 3C 120 on December 12, 1969. b) 3C 371 on June 8, 1969. c) 3C 454.3 on September 6, 1969. In each case the field shown is $11' \times 20'$ in extent, with north at the top and east at the left; the source is just to the left of the white pointer. On the better plates of our series, nebulosity can be seen surrounding 3C 120 and 3C 371, but it is too faint to reproduce well.

a young, super-luminous object, still rich in "irtrons" and thus violently active over the entire electromagnetic spectrum.

RADIO SOURCE 3C 371

Wyndham (1966) has identified the radio source 3C 371 with a 14th magnitude N galaxy. (In general, the nucleus of an N galaxy is larger relative to its envelope than that of a Seyfert, and the envelope is more amorphous. The N's are even bluer than the Seyferts, and they are strong low-frequency radio sources.) Sandage (1966a), on the basis of one weak emission line, concluded that the galaxy displayed a red shift of $z=0.0500$, a value later confirmed as $z=0.0457$ by the Soviet astronomers Dibai and Esipov (1969), who identified a second emission line. The distance to 3C 371 is thus about 138 Mpc.

In 1967 Oke (1967) reported observations with the 200-inch telescope indicating that the brightness of the galaxy had increased about 1.0^m between August of 1965 and July of 1967. Oke attributed this variability entirely to the star-like nucleus, which in 1967 had a visual magnitude of $14.4.^m$ The surrounding galactic envelope had a brightness of only $16.0.^m$ The intrinsic luminosity of this N galaxy apparently lies midway between typical Seyferts and the quasars. In addition to the long-term change, Oke found variations of one- or two-tenths of a magnitude on a time scale of a few days.

Oke's discovery of the variability of 3C 371 prompted Usher and Manley (Usher and Manley, 1968; Usher 1969) to search the Harvard plate collection for earlier images of the object. Fig. 2b is plotted from Usher's (1969) tabulation of these results, and it also includes observations Usher collected from Greenwich, Lowell Observatory, Sternberg, Maria Mitchell Observatory, and Heidelberg (the published Sternberg data, which appeared anomalous, have been corrected here by -0.8^m as the result of private communication between Usher and the present writers). An obvious feature of the light curve is the decline of about 1.7^m between 1895 and 1923. There is then evidence of a slow increase between 1923 and the early 1960's, followed by a sharp decline in 1966 and perhaps an even more precipitous rise in 1967. It is reassuring that values of m_{pg} estimated by the writers from Oke's (1967) photoelectric scans in 1965 and 1967 precisely confirm this rapid rise.

The University of Florida observations, which began in 1968 and continue through the present, are shown at the right of Fig. 2b and in expanded form in Fig. 3b. Apparently the magnitude range of 3C 371 in 1968-1970 was about the same as in 1965-1967, with a total amplitude of about 1.0^m. The rapid changes of the past few years suggest that not only is the scatter of the older data real, but that many similarly rapid variations must have been missed because of the gaps in the observations. Fig. 3b suggests that during 1969 there was a quasi-cyclic fluctuation with a period of 3-4 months. Thus far in 1970 the changes have been less than $\pm 0.2^m$; whether this quiescence is the prelude to a decline in brightness remains to be seen. The University of Florida photometry is based on a calibration obtained by photographing Selected Area 6 on the same plate as the galaxy on September 4, 1969. The zero-point of our magnitude sequence was tied to a photoelectric observation of one of the comparison stars reported by Usher (1969). Fig. 4b shows 3C 371 and the surrounding field of comparison stars.

Kellerman and Pauliny-Toth (1968) list 3C 371 as variable in the radio region, although apparently not enough observations were available to establish a meaningful curve of flux vs. time.

RADIO SOURCE 3C 454.3

The radio source 3C 454.3 is a typical quasar. According to Dibai and Esipov (1969) it has a red shift $z=0.86$, corresponding to a distance of 2580 Mpc. In 1966 Sandage (1966b) reported that 3C 454.3 was an optical variable with an amplitude of 1.05^m between 1954 and 1965, a conclusion based on three photographic plates plus photoelectric observations made in late 1965.

Sandage's discovery prompted Angione (1968) to trace the history of 3C 454.3 back to 1900 in the Harvard plate collection. Fig. 2c is adapted from Angione's study, which also includes the points in 1954 and 1965 from Sandage. The principal features of this survey appear to be outbursts in 1912, 1942, 1953 and, possibly, 1936 and 1949. The latter peaks, if genuine, would lend credence to a periodicity of 6 years, all of the missing flares lying in gaps in the observations; this highly speculative assumption predicts a new maximum in 1972.

The Florida observations, which began in 1968, are included in Fig. 2c and in expanded form in Fig. 3c. The quasar and its sur-

rounding field are shown in Fig. 4c. It can be seen that at present 3C 454.3 is hovering near minimum light, with fluctuations of 0.2^m or 0.3^m about an average of 17.0^m. The total range of the object during the 70-year span of data has been an impressive 2.3^m The Florida photometry, like that of Angione, has been based on a sequence of three comparison stars whose photoelectric UBV magnitudes were published by Sandage (1966). As a result, the magnitudes that are shown are B magnitudes, rather than the usual m_{pg} values.

The source is also an active radio variable (Kellerman and Pauliny-Toth, 1968). A major radio outburst occurred in 1967-1968 at wavelengths ranging from 2-40 cm.

Summary

University of Florida observations in the period 1968-1970 show continued fluctuations in the light of three extragalactic radio sources previously reported as optical variables. The most active of the sources during this period was the N galaxy 3C 371, while the least active was the quasar 3C 454.3. A Seyfert galaxy, 3C 120, displayed an intermediate level of activity. Studies of this kind may eventually point to the correct evolutionary relationships between quasars and galaxies. Of particular importance is the accumulation of sufficient data to permit correlations to be established between the radio and optical outbursts of unstable extragalactic objects.

Acknowledgments

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Behavioral Changes in Dolphins in a Strange Environment

Blair Irvine

In recent years, dolphins of three species have been conditioned to respond to acoustic signals and perform reliably while swimming untethered in the open sea (Bailey, 1965; Norris, 1965; Hall, 1970).

This report describes abrupt and radical changes which were observed in 10 dolphins, eight *Tursiops truncatus* and two *Lagenorhynchus obliquidens*, at the Marine Bioscience Facility, Point Mugu, California, when they were moved from concrete tanks to net pens in turbid waters of Mugu Lagoon prior to their initial open sea release. It also notes four separate instances where animals wandered away from the pen area and behaved in a manner inconsistent with previous conditioned responses.

The dolphins had been in captivity for periods ranging from three weeks to three years prior to commencement of conditioning. Only one had previously been conditioned for another experiment.

Preparatory to open sea release, all were trained to (1) come to and touch an acoustic "recall" signal when it was placed in the water at any point around the perimeter of the tank, (2) swim through gates to adjacent pens whenever the recall signal was placed in the water at the gate, and (3) allow themselves to be handled over all parts of the body by persons in the water or at the side of the tank. Usually 2-4 months were required to establish these responses. Once a dolphin would perform all the required behaviors promptly and consistently, it was considered ready for the final phase of training prior to open ocean release. During this phase, it was released into the ocean-fed lagoon adjacent to the Facility.

The training area in Mugu Lagoon is approximately 600 meters square with an average depth of 3-6 meters at low tide (see Fig. 1). A mud bottom and insufficient water exchange through a narrow channel to the ocean usually reduce underwater visibility to less than 60 centimeters. Background noise levels in the lagoon, produced by a variety of organisms, snapping shrimp, mussels, croakers, etc. vary with the time of day and the tide. The overall sound pressure levels, as measured with an AN/DQM-1A underwater sound level meter, range between 0-10 dB (re: 1 microbar).

The measurements cover a band from 40 Hz-40 kHz; however, most of the ambient in the lagoon is below 1 kHz.

During lagoon training, animals were maintained in a series of floating pens constructed of steel torpedo netting hung from interconnected steel pontoons. Behavior patterns learned in the concrete tanks were re-established, first in 4 $\times$ 6 meter pens, and then in a 17 $\times$ 19 meter enclosure connected with each small pen by an opening 120 cm wide by 150 cm deep. The depth of the large enclosure was between 2-4 meters, varying with the tide.

When a dolphin in the lagoon pens performed at the levels established in the concrete tanks, it was released into the open lagoon for long distance recall training and for acclimation to the presence of outboard boats.

Ten dolphins were moved from their concrete tanks to the lagoon pens between August 1966 and February 1969. All exhibited immediate behavioral changes, swam slowly in tight circles at the surface, refused to respond to commands and often refused to eat. The dolphins continued to appear lethargic and unresponsive to the presence of their handlers for from 6-48 hours, after which their behavioral responses gradually returned to previously established levels. For the first few days, some of the dolphins also appeared to experience difficulty locating fish in the turbid water. When these animals swam toward fish thrown into the water, hydrophones often did not pick up echo-location sounds, and the dolphin often passed by without finding the fish. After behavioral responses returned, however, apparent sonar clicks were quite evident, and the dolphin readily found the fish.

Obvious behavioral changes also were evident in other situations, twice when animals escaped from their pens prior to their first release, and twice when animals wandered away from their trainers during the early stages of training in the open lagoon. In all instances the animals exhibited similar behavior. Each swam slowly, primarily on the surface, at a speed estimated to be less than 1 kilometer per hour. Each was found within 3-20 meters of the shoreline in approximately 50-100 centimeters of water. In all instances the dolphins appeared sluggish and unresponsive to their trainers, refused to respond to previously conditioned recall signals and showed only occasional interest in fish thrown near them. Their behavior was similar to that exhibited when they were first moved

Fig. 1. Aerial view of the Marine Bioscience Facility and pontoon pen complex in Mugu Lagoon. Lettering in lower left denotes area where the *T. truncatus* Redeye (R) and the *L. obliquidens* Peanuts (P-1) were found after escaping from the pens. Lettering in top left of picture marks where the *T. truncatus* Fetch (F) and Peanuts (P-2) were found after wandering away during early boat training.

to the lagoon and was reminiscent of sick animals shortly before death in that they appeared physically listless and without their usual food drive. Each dolphin swam in random patterns but stayed close to shore and within approximately 100 meters of the area where it was first located. Even though two of the porpoises had previously been conditioned to swim next to an outboard motor boat, all the animals swam away when a boat approached within 3 meters. None took evasive action if the boat remained farther away.

The animals were returned to their pens in one of two ways. A young female named Fetch (208 centimeter *Tursiops*), who evaded all other capture attempts, was finally recaptured after a handler

jumped on her from a silently drifting boat and dragged her a short distance to the beach where she could be secured in a stretcher for transport to the pens. A young 216 centimeter male *Tursiops* named Redeye readily swam to the side of an older fully trained *Tursiops* brought into the area behind a boat, and subsequently followed closely as the older animal was led back to the pens, whereupon both dolphins entered on command without hesitation.

A young, 220 centimeter male *Lagenorhynchus* named Peanuts wandered away twice. The first time, shortly after being released into the large enclosure, he escaped and swam approximately 100 meters away, along the shore (see Fig. 1). When Peanuts failed to respond to acoustic recall commands, his trainer waded to him and held the unresisting animal while other personnel brought a stretcher. Two weeks later the animal responded normally to recall commands around the perimeter of the pontoon pens. However, after following a boat a short distance he wandered away. This time he was returned to the pens with the same trained *Tursiops* who had been instrumental in returning Redeye.

DISCUSSION

Although conclusive proof is not available, it seems improbable that the observed behavioral changes are correlated with the length of time in captivity. All 10 animals reacted similarly when introduced into the lagoon. Because none would initially respond to any conditioned stimuli, it was impossible to obtain quantitative data for response comparisons. There also seemed to be no obvious correlation between time in captivity and the behavior of the animals that wandered. Fetch, Redeye and Peanuts had been in captivity 8, 14, and 16 months respectively, prior to introduction into the lagoon. Five dolphins had been in captivity for shorter periods, while two had been held for more than 2 years. Only Redeye was thought to have been recently weaned at time of capture.

During training, all were periodically caught and lifted from the tank so that routine blood samples could be taken. Because their behavior always returned to normal within minutes after reentering the water, it seems reasonable to assume that the handling involved in carrying them from their tank to the lagoon did not significantly affect their behavioral responses.

Norris (1965) reported that a *Tursiops gilli* released in Hawaii had to be literally forced out of the pen for the first time and was

initially unwilling to move far away. Our experiences with the release of eight *T. truncatus* and two *L. obliquidens* have been similar to Norris's in that the animals were initially hesitant to leave the pen area. Sometimes they had to be conditioned to leave the area gradually over a period of weeks. Although in some cases, the presence of other animals inside the holding pen complex may have contributed to their reluctance to leave, the same unwillingness was observed with no other dolphins present. After initial release from the pen complex, the animals at Point Mugu were usually worked around the pontoon enclosure for several days or more before being gradually led away from the pens.

The behavior of the dolphins that wandered away from the pen area in the early stages of training appeared similar to that observed when the animals were initially introduced into a lagoon pen. They were lethargic and unresponsive to either their handlers or previously conditioned stimuli. Apparently a sudden change in local environment, such as introduction into the murky and biologically noisy lagoon waters, or entry into a foreign area of the lagoon was significantly upsetting to the animal, and therefore was responsible for the breakdown in responses. Other investigators (Caldwell et al., 1962; Essapian, 1953; McBride and Hebb, 1948) have described behavioral variations due to changes in local environmental stimuli as fear or fright reactions characterized by tight schooling and rapid swimming, apparently a modified flight response. Such observations, however, were made of groups of animals subjected to only occasional and slight environmental variations (i.e. the insertion of an object into the tank) whereas the subject animals at Point Mugu were introduced into markedly new and different surroundings.

Upon returning to the pens, the behavior of all four animals cited in this report rapidly reverted to previously conditioned response levels and they ate readily. Surroundings to which the animal had previously been acclimated provided apparent security, or at least increased the amount of responsiveness that was lacking only a short time before. Animals previously exposed to the lagoon have not exhibited lapses in behavioral responses when reintroduced after an extended stay in the concrete tanks on shore. The conclusion that something familiar can reduce the trauma was also supported by the fact that two of the wayward animals appeared to become more responsive when approached by another dolphin from

the pen complex. In each case, the wandering dolphin was observed to become more alert and active, and returned to the pen close behind the boat which had shortly before caused a mild but consistent avoidance response.

The fact that all four animals entered shallow water and remained there is especially noteworthy. The animals that escaped swam immediately into a nearby shallow area, but the animals that wandered during boat training swam approximately 600 meters through water 3-6 meters deep before moving into the shallows (see Fig. 1). Why both animals were located in approximately the same area on the far side of the lagoon cannot readily be explained. For *T. truncatus* to seek shallow water might be explainable since this species is often found close to shore in areas along the Gulf of Mexico and Florida. However, *L. obliquidens* is a pelagic species of the Pacific Coast and is rarely seen in shallow water, except in isolated cases where sick or injured animals sometimes beach themselves. Members of other cetacean species, *T. truncatus* included, are known to beach themselves when sick (Ray, 1961; Ridgway and Johnson, 1965) and for other unexplained reasons (Kritzler, 1952; Slijper, 1962). The animals cited in this report were in water shallow enough to have been stranded by surf or tidal conditions, or they could have been mistaken for dolphins trying to beach themselves. Consequently, there may prove to be a parallel between the behavior cited here and that of cetaceans which beach themselves in the wild.

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Effects of Progressive Relaxation on Alcoholic Patients

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At the Bureau of Alcoholic Rehabilitation's Treatment and Research Center in Avon Park (referred to as the Center), one of the major desired effects of the counseling process has been to reduce in its alcoholic patients the excessive anxiety which seemed to be commonplace among them and appeared to hinder them from deriving full potential benefit from treatment. This excessive anxiety also was thought to be a major contributory factor in causing patients to leave the Center against medical advice (AMA). Anxiety seemed to be particularly high during a patient's first week at the Center, when he had to adjust to the hospital treatment and routine. In order to try to reduce excessive anxiety in patients, a progressive relaxation technique was employed. This technique was introduced at the Center by Mr. Charles Dils, former Bureau Clinical Psychologist.

Progressive relaxation is a procedure taught to patients to enable them to relax their entire body through practicing the relaxation of the various muscle groups as units. The physical relaxation is supposed to contribute to a mental state of reduced anxiety. This method has been reported to be effective for the treatment of neurotic disorders which involved a great deal of anxiety (Watkins, 1965). For example, in one study, a group of 37 alcoholic patients was treated by aversion and relaxation therapy, while another group of 25 patients was treated by aversion therapy alone. At 12 months follow-up, 59 per cent of the group which received relaxation therapy was classified as abstinent or improved, while only 50 per cent of the group which did not receive relaxation therapy was classified as abstinent or improved (Blake, 1967).

Relaxation therapy was employed at the Avon Park Center as an adjunct to other treatment, primarily group therapy in a therapeutic community setting (see Thomas, no date, for a further description of the treatment at the Avon Park Center) in order to enable patients to reduce their anxiety to an optimal or manageable level during their hospitalization. It was felt that if this could be done, patients would have better control over their behavior and a better chance to benefit from other treatment at the Center.

Specifically, it was felt that if relaxation therapy were beneficial for patients then the benefits should be directly reflected by (1) a reduction in the number of patients who drop out of treatment and leave the Center AMA, particularly at the beginning of treatment; (2) patients being able to sleep and rest more fully at night; and (3) the improved adjustment of patients between intake and discharge at the Center.

METHOD

Subjects. At the Center, patients are assigned to counselors for guidance on a rotating basis, usually at the rate of a group of twelve patients per month. When patients assigned to one counselor are discharged, he is assigned the next twelve patients to be admitted. The study subjects were all 72 patients (74 per cent male, 26 per cent female) consecutively assigned to the first author for small group and individual counseling between October, 1968 and May, 1969. The first 24 and the last 12 patients received no progressive relaxation treatment (NPRT Group), and the middle 36 patients were given progressive relaxation treatment (PRT Group). All 72 patients received the medical, individual and group therapy that was customarily given at the Center.

Measurement. In order to be able to analyze a detailed profile of the adjustment of subjects, the results of the patient responses on selected scales of the Cornell Medical Index Health Questionnaire (CMIHQ) and the Cornell Medical Index, N2 Form (CMIN2) were analyzed (Brodman, Erdman, and Wolfe, 1949; Weider, Wolfe, Brodman, Mittleman, and Wechsler, 1948). On both of these questionnaires the higher a patient's score, the greater his indicated pathology.

The percentage of "quiet nights" (or equivalent) notations by a night nurse in the daily medical record of the patient was used as an indicator of his general anxiety level. Additionally, it was felt that it was generally desirable for patients to rest at night, since this would improve their physical recuperation and their alertness during therapy.

The number of days that a patient was in treatment at the Center was also used as a measure. The usual treatment schedule called for 28 days stay, although some, depending upon their needs,

stayed longer. Generally, 25-28 days were considered of optimal benefit to the patients.

The type of discharge recorded in a patient's medical records was used as the index of whether or not a patient completed treatment or left against medical advice (AMA). Completing full treatment meant that the patient had stayed for the full 25-28 days of scheduled treatment usually given at the Center, or had derived all of the benefit from Center treatment that he was judged potentially capable of receiving. Leaving the Center AMA consisted of a patient leaving treatment due to a lack of sufficient motivation to continue treatment, environmental causes, anxiety and resistance because of disturbing insight, or self assertion of the patient.

Analysis. The techniques of data analysis included: Chi square, Fisher's exact test, and an interpolated median. Fisher's exact test was used when all frequencies were too low to yield meaningful results with chi square analysis. Fisher's exact test results in a direct probability (Hays, 1963).

The McNemar and binomial tests were used to assess changes between intake and discharge on selected characteristics. The binomial test was used when frequencies were too low to yield meaningful results with the McNemar test (Siegel, 1956).

Progressive Relaxation Therapy. The progressive relaxation treatment (PRT) for the patients who received this experimental therapy consisted of playing for them a 20-minute tape recording specially adapted for alcoholic patients. The recording was a set of instructions, spoken by a male voice, which started with a brief explanation that the relaxation technique being described was a way of reducing tension and anxiety. It was stated on the tape that this method of relaxing was more desirable than using drugs or artificial means since it was "natural." Also stated was the suggestion that this method could help with drinking problems and should be used by the patient at night or whenever he felt the need to relax. The tape instructed the patients to relax a specific muscle group, and then told them what sensations to expect. Relaxation suggestions were spoken softly and with reworded repetition. After one muscle group was dealt with, another would become the focus of the taped instructions. The procedure continued until all major muscle groups were covered. The tape ended by reversing the

nature of the instructions. This was in order to end the treatment by bringing the patients back to a normal activity level.

See the acknowledgment for the source of the progressive relaxation recording.

Procedure. The progressive relaxation treatment recording was played for the PRT Group at the end of their small group counseling sessions during their first week as inpatients. The PRT Group heard the tape a total of three times, usually between 1:30-2:00 P.M. in the afternoon, and sat in chairs while listening. The group which received no progressive relaxation treatment (the NPRT Group) received additional time for small group counseling instead of hearing the relaxation tape. There were approximately 12 patients present for both the PRT and NPRT Groups in each small group meeting.

RESULTS: PATIENT CHARACTERISTICS AT INTAKE

Personal and Social Characteristics. The subjects in the PRT and NPRT Groups did not significantly differ from each other on any personal or social characteristic at the time of hospital admission.

Overall, subjects were predominantly male (74 per cent). More of the subjects had a marital divorce, annulment or separation (50 per cent) than were married and living with their spouse (40 per cent).

The Index of Value Orientation was used to measure social class status (McGuire and White, 1955). About 46 per cent of the subjects were middle class or higher.

The religious preference of the subjects was predominantly Protestant (67 per cent), with about 15 per cent Catholic, 1 per cent Jewish, 8 per cent "others," and 8 per cent expressed no religious preference at all.

Most of the subjects (51 per cent) had been arrested during the year prior to intake due to drinking. This was not an unusual percentage of arrests for alcoholic patients.

At the time of admission, the median age of the subjects was 47, their median number of years of education was 12, and the median number of weeks since they had attended an Alcoholics Anonymous meeting was 9.5.

Vocational Characteristics. The subjects in the PRT and NPRT Groups did not differ significantly on any vocational characteristic at intake. Over half (51 per cent) of all subjects were employed or housewives, and about 46 per cent were unemployed. The remaining patients were handicapped, retired, or otherwise not a potential part of the labor force.

Only 31 per cent of the subjects had an occupational level of "white collar" or higher.

The median length of time the subjects had held their last job was .77 years (about 9 months).

Drinking Characteristics. The PRT and NPRT Group subjects did not significantly differ in the number of weeks since their last drink prior to Center admission (median=2.0 weeks) or in the number of years they had been drinking (median=25.0 years), but the groups did differ in the number of years their members had lost control of drinking.

The median number of years subjects in the PRT Group had lost control of drinking was 10. This was over twice the figure for the NPRT Group, whose subjects had lost control of their drinking for a median of about 4 years. Because of this difference, the outcome data were examined on the basis of whether or not subjects received progressive relaxation *and* whether patients were above or below the *total* median number of years (5.5) subjects had lost control of their drinking. This was in order to control for the loss of control of drinking variable, and, therefore, to isolate the effect of progressive relaxation. In the PRT Group, 22 patients were above this total median, 13 below it, and information was not available on this variable for one patient. This patient, however, was included for total group analyses. In the NPRT Group, 13 patients were above the total median and 23 were below it.

RESULTS: PATIENT CHARACTERISTICS AT HOSPITAL DISCHARGE RELATIVE TO PROJECT OBJECTIVES

Objective #1, to reduce the number of patients who drop out of treatment and leave the Center AMA, particularly at the beginning of treatment. When the incidence of AMA discharges during the first two weeks of treatment for patients who had lost control of their drinking for more than 5.5 years was compared between

the study groups, it was found that only one patient (out of 22) left the Center AMA in the PRT Group, while 4 (out of 13) left AMA in the NPRT Group. The frequency differences were statistically significant ($P = .0486$, Fisher's exact test). There was no significant difference in the incidence of AMA discharges between groups for patients who had lost control of their drinking for less than 5.5 years, nor between the PRT and NPRT Groups overall. In total, four patients out of the 36 members of the PRT Group left the Center AMA and 5 of 36 in the NPRT Group.

Overall, patients in the PRT Group had a higher average stay at the Center (25.4 days) than the NPRT Group (23.6 days). The difference was not statistically significant ($t = .99$, $df = 70$, $P > .05$) between the groups.

However, the NPRT Group's overall average days' stay of 24 was attained by having most patients both above (19.4 per cent) or below (41.7 per cent) the customary (and assumedly optimal) hospitalization duration of 25-28 days instead of within it. In fact, only 38.9 per cent (a minority), of NPRT Group patients were hospitalized for the recommended length of time. This contrasted strikingly with the PRT Group, where 75 per cent stayed at the Center 25-28 days. Chi square analysis using the three categories of 25-28 days, over 28 days, and under 25 days, revealed a significant difference ($X^2 = 10.7$, $2df$, $P < .01$) between the PRT and NPRT Groups.

When patients were compared by study group *and* by number of years patients had lost control of drinking a significant finding resulted. Patients in the PRT Group who had lost control of their drinking for more than 5.5 years averaged 25.2 days at the Center, while those in the NPRT Group stayed only 19.2 days. The difference was statistically significant ($t = 2.535$, $df = 33$, $P < .05$). There was not a statistically significant difference between study groups for patients who had lost control of drinking for less than 5.5 years; those in the PRT Group averaged 26.08 days hospitalization and those in the NPRT Group averaged 26.13 days hospitalization.

Objective #2, to enable patients to sleep and rest more fully. The patients who had lost control of drinking for more than 5.5 years in the PRT Group had a significantly ($t = 2.26$, $32df$, $P < .05$) higher average percentage of "quiet nights" (99.2 per cent) than those in the NPRT Group (93.2 per cent). Although the percent-

ages of "quiet nights" in both groups, and subgroups, were high (over 93 per cent), the index of "quiet nights" was used, not only as a direct measure, but as a general indicator to reflect anxiety and night time unrest. It was a direct measure only of disturbances severe enough to come to the attention of the night nurse, and this type of disturbance would be expected to be relatively infrequent.

A further indication of whether or not Objective #2 was attained was that the PRT Group, but not the NPRT Group, showed a significant increase in the percentage of subjects with a low "Fatigability" scale score on the CMIHQ. The items on this scale, in particular, pertained to symptoms which would be effected by the quality of night time sleep and rest.

Objective #3, to improve the adjustment of patients between intake and discharge. Indices of adjustment were the intake-discharge changes on selected scales of the CMIHQ and CMIN2.

No patterns were evident when groups were divided on the basis of number of years lost control of drinking which were not also present when comparing groups as a unit. The PRT Group showed a significant "favorable" change on the "Fatigability" and "Anger" scales of the CMIHQ, while the NPRT Group showed a significant change on the "Depression" and "Anger" scales. Each Group showed significant score decreases (symptom reductions) on two scales, one ("Anger" scale) in common with each other.

The same type of analysis as was used for the CMIHQ scales was utilized for the CMIN2 scales. The PRT Group showed significant "favorable" changes on two scales, "Startle" and "Hypochondriasis and Asthenia." The NPRT Group did not show a significant change on any scale.

Discussion and Conclusions

It was considered beneficial for the alcoholic patient to retain him in treatment for his scheduled hospitalization period. Premature departure was usually considered as undesirable, as was being hospitalized much beyond the customary stay.

Significantly more alcoholic patients who received progressive relaxation treatment (PRT Group), when compared with those who did not (NPRT Group), stayed the optimal length or time in treatment (25-28 days). Furthermore, for patients who had lost

control of their drinking more than 5.5 years, those in the PRT Group, on the average stayed a significantly more favorable length of time (25 days, versus 19 days).

Therefore, generally, PRT did seem to fulfill its intended purpose of retaining patients in treatment, and for an optimal length of time.

It was generally considered undesirable for a patient to leave treatment against medical advice (AMA), since this type of departure meant that a patient was leaving even though the treatment staff felt he could still benefit from further therapy. The PRT Group, as compared to the NPRT Group, overall had numerically fewer patients leave AMA (four, versus five) and significantly fewer leave AMA during the first two weeks of treatment (one, versus four) of patients who had lost control of their drinking for more than 5.5 years. PRT did, then, seem to have an effect on the early AMA discharge rate of some patients.

Night time disturbances severe enough to warrant a nurse's attention were considered indicative of excessive (undesirable) patient anxiety and, more directly, of a patient not receiving proper rest. It was generally considered desirable for a patient to have few night time disturbances, or, a maximum number of nights ("quiet nights") when no disturbance was recorded by a night-nurse. PRT Group patients who had lost control of their drinking for more than 5.5 years had a significantly higher incidence of "quiet nights" than the same type of NPRT Group patients. Clearly, PRT probably increased the number of "quiet nights" of some PRT Group patients and, therefore, may have also reduced their excessive anxiety.

The Cornell Medical Questionnaires, Index and N2 forms, give an assessment of personal adjustment. Considering both forms together, the PRT Group showed four significant scale changes (between hospital intake and discharge) in an improved direction, while the NPRT Group showed only two significant changes. The PRT Group showed a wider range of significant improvements in adjustment.

The pattern of results indicates strongly that Progressive Relaxation Treatment, as an adjunct to other therapy, seems to have value for alcoholic patients in general, and, in particular, for those

who have lost control of their drinking for relatively long periods of time.

The pattern of results seemed to provide a basis for continuing the use of PRT at the Center, and continued research upon its effects.

ACKNOWLEDGMENTS

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Redescription of *Prionotus beani* (Pisces, Triglidae)

George C. Miller and Dana M. Kent

The triglid fishes of the western North Atlantic Ocean include three closely related cognate species in the *Prionotus alatus* species group: *Prionotus alatus* Goode and Bean (1883); *Prionotus beani* Goode *in* Goode and Bean (1896); and *Prionotus paralatus* Ginsburg (1950). The *alatus* species group is distinguished from the other species of *Prionotus* in the Atlantic by the following combination of characters: pectoral fin with distal edge emarginate; lower joined pectoral rays elongate in juveniles; incomplete squamation on chest in adults; and serrations on anterior three to five dorsal spines.

The identification of the western Atlantic searobins is difficult in spite of recent reviews of the Triglidae by Ginsburg (1950) and Teague (1951). Specimens of *Prionotus* from Texas were considered by Teague to be no more than variants of *P. beani,* but were named by Ginsburg as a new species, *P. paralatus.* The American Fisheries Society checklist (1960) lists both *P. beani* and *P. paralatus* from United States waters. Ichthyologists have been perplexed as to the identification of the two species (Caldwell and Caldwell, 1964, p. 39), particularly when the specimens are small.

In this paper we give a key to the *alatus* species group, redescribe *P. beani,* compare *P. beani* with its cognates, and show the relationship and distribution of the three species.

This project was undertaken at the BCF Tropical Atlantic Biological Laboratory, in cooperation with the Dade County (Miami, Fla.) Public Schools, Laboratory Research Program. James Böhlke, Harvey Bullis, Jr., Daniel Cohen, Bruce Collette, Robert Gibbs, Ernest Lachner, Milton Lindner, Donald Moore, and C. Richard Robins made available to us triglid specimens for examination. Frederick H. Berry and Robert V. Miller reviewed the manuscript. Grady W. Reinert prepared the illustrations.

Methods

The abbreviations of museums, biological laboratories, and fishery or research vessels are: Academy of Natural Sciences of Phila-

delphia, ANSP; United States National Museum, USNM; Museum of Comparative Zoology, Harvard University, MCZ; U.S. Bureau of Commercial Fisheries Biological Laboratory, Galveston, Texas, BLGT; U.S. Bureau of Commercial Fisheries Tropical Atlantic Biological Laboratory, Miami, Florida, TABL. Fishery vessels: *Gus, G*; *Belle of Texas, BT*; and *Miss Angela, MA*.

Measurements, counts and definition of spines follow Miller (1965, p. 259; 1967, pp. 17-25). Gillraker counts: all rakers and tubercles on the epibranchial, ceratobranchial, and hypobranchial bones of first gill arch; raker at angle of first gill arch included in ceratobranchial counts; all rakers and tubercles on lower limb of the second, third, and fourth gill arches. Posterior dorsal or anal softray, split to base, counted as a single ray.

Following lengths measured from premaxillary symphysis: standard length, to posterior edge of hypural plate; head length, to posteriormost point of flexible margin of opercle. Orbital measurements: width, greatest horizontal distance between bony rims of orbit; depth, greatest vertical distance between bony rims of orbit; interorbital width, least dorsal width between bony rims of orbits. Pectoral lengths: from apex of ventralmost joined pectoral ray and first free ray to distal ends of longest upper and longest lower joined pectoral rays, and to distal ends of first (dorsalmost), second, and third free pectoral rays. Pelvic fin length: from base innermost ray to distal end of pelvic fin. Preopercular spine length: from apex of angle with head to distal end of spine.

Squamation: zone 1, posterior to transverse line through base of innermost pelvic rays; zone 2, between base of innermost and base of outermost pelvic rays; zone 3, between base of outermost pelvic rays and base of anteriormost free pectoral rays; zone 4, anterior to transverse line through base of anteriormost free pectoral ray (Fig. 1). Chest refers to zone 4, breast to zones 2 and 3, and abdomen to zone 1.

Rostral exsertions: elongation of first infraorbital bones anterior to premaxillary symphysis. Nasal spines: usually paired on snout between anterior nasal pores.

KEY TO THE *Alatus* SPECIES GROUP

A. Nasal spines present.
 a. Longest lower joined pectoral ray greatly exceeding 50% of standard

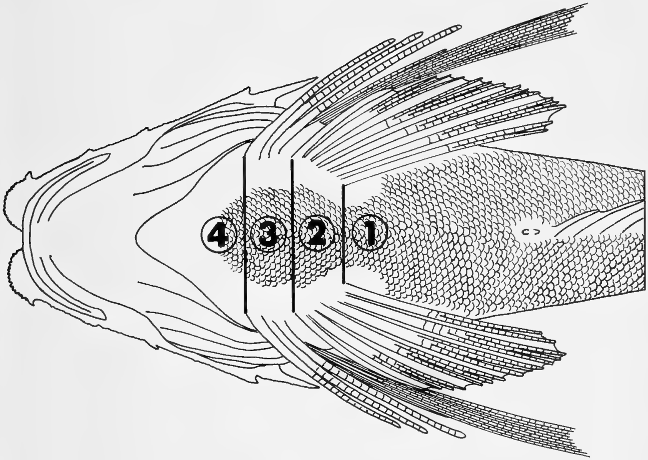

Fig. 1. Chest squamation zones in the *Prionotus alatus* species group.

length (Mean = 68.4% SL) in specimens larger than 65 mm.; scales on abdomen not extending anteriorly past a transverse line through bases of innermost pelvic rays (95.5% of specimens examined); distribution off United States from Virginia to Louisiana, Campeche Bank, and Greater Bahama Bank ..... *Prionotus alatus* Goode and Bean

aa. Longest lower joined pectoral ray less than 50% of standard length (Mean = 42.5% SL) in specimens larger than 65 mm.; scales on chest and breast extending anteriorly past a transverse line through bases of outermost pelvic rays (92.8% of specimens examined); distribution, Panama to Brazil .... *Prionotus beani* Goode

AA. Nasal spines absent.

b. Preopercular spines long (Mean = 12.3% SL) in specimens over 65 mm. SL; scales on chest not extending anteriorly beyond transverse line between bases of outermost pelvic rays (66% of specimens examined); distribution, western Gulf of Mexico from Mississippi delta to Gulf of Campeche .... *Prionotus paralatus* Ginsburg

bb. Preopercular spines short (Mean = 9.2% SL) in specimens over 65 mm. SL; scales on chest extending anteriorly beyond transverse line between bases of outermost pelvic rays (93% of specimens examined); distribution, Panama to Brazil .... *Prionotus beani* Goode

TABLE 1

Distributions of dorsal, anal, and joined pectoral rays in the *Prionotus alatus* species group

Species	Dorsal Spines				Dorsal Softrays			Anal Softrays		Joined Pectoral Softrays	
	8	9	10	11	11	12	13	10	11	12	13
P. alatus	1	2	70		2	71			73	8	65
P. paralatus		1	43		1	42	1	1	43	7	37
P. beani			83	1	3	81		1	82		83

Prionotus beani GOODE

(Figs. 2-6)

Goode *in* Goode and Bean, 1896, p. 468, pl. 112, figs. 383 and 383b. Holotype: 110 mm. SL, USNM 39318, *Albatross* Station 2120, 11°07′ N. lat., 62°14′30″ W. long., 73 fathoms, off Trinidad. [The holotype of *P. beani* was originally given the manuscript name *P. trinitatis* by Goode and Bean. Before Oceanic Ichthyology was published, Bean died and Goode honored his colleague by naming this searobin *P. beani* instead of *P. trinitatis.* Unfortunately the name *P. trinitatis* was not changed to *P. beani* in the Atlas, p. 24 and Figs. 383 and 383b. *P. beani* and *P. trinitatis* are based on the same specimen, cataloged USNM 39318; the original description of *P. beani* refers to the illustration of the holotype as Fig. 383; and in the bottle with the holotype of *P. beani* is a label with the name *trinitatis. P. beani* Goode is a senior objective synonym of *P. trinitatis* selected by Ginsburg (1950) on the basis of page priority.]

Counts and Measurements. Frequencies of counts and measurements are in Tables 1-8. Ranges of the counts are followed by the modal count in parentheses. Dorsal spines X-XI (X). Dorsal softrays 11-12 (12). Anal softrays 10-11 (11). Pectoral joined softrays 13. Gillrakers and tubercles on first gill arch: epibranchial, 2-3 (2); ceratobranchial, 9-14 (11); hypobranchial, 2-8 (4); lower limb, 12-18 (15-16); total rakers and tubercles 14-21 (18). Tubercles or rudiments of lower limb: second gill arch, 10-13 (11); third gill arch, 8-11 (9); fourth gill arch, 6-10 (8). Chest squamation zones 2-4 (3-4).

Description. Rostral, second, and third infraorbital spines present. Nasal spines present or absent. Preocular spine strong, elevated, sometimes preceded by serrated ridge. Postocular spine or spines (usually two or more) low, retrorse, at termination of serrated ridge. Parietal spines short retrorse, at termination of small, finely serrated ridge, or only triangular shaped ridge present. Posttemporal spine short at termination of long, low ridge. Preopercular, preopercular remnant, opercular and cleithral spines, strong. Dermosphenotic and pterotic spines short, low, retrorse if present at termination of a short highly serrated ridge. Eye large, interorbital width narrow, strongly concave, occipital pit developed.

TABLE 2
Distribution of gillrakers and tubercles on epibranchial, ceratobranchial, and hypobranchial bones of the first gill arch of the *Prionotus alatus* species group

Species	Epibranchial					Ceratobranchial									Hypobranchial						
	1	2	3	4	5	7	8	9	10	11	12	13	14	15	2	3	4	5	6	7	8
P. alatus	3	29	27	7		1	0	3	15	22	16	5	3	1	8	25	17	14	2		
P. paralatus	4	37	2					5	23	14	1				8	19	15	1			
P. beani		45	37					4	13	39	17	7	2		1	14	35	15	12	4	1

TABLE 3

Distribution of gillrakers and tubercles on lower limb, and total number on first gill arch of the *Prionotus alatus* species group

Species	Lower Limb								Total Number on 1st Gill Arch								
	11	12	13	14	15	16	17	18	13	14	15	16	17	18	19	20	21
P. alatus	1	1	11	13	16	16	7	1		2	9	7	14	16	11	6	1
P. paralatus	2	5	13	18	4	1			3	7	9	19	3	2			
P. beani		1	1	9	26	26	12	7		1	1	6	16	29	14	12	3

First 3-5 dorsal spines serrated on leading edge or laterally. First dorsal softray partially serrated. First gill arch: epibranchial bone fused on anterior half with pseudobranch and roof of mouth; usually tubercles or single raker on epibranchial; rudiments offset between rakers on outer face of ceratobranchial posteriorly, becoming indistinguishable with raker rudiments anteriorly. Vomerine and palatine teeth present.

Pigmentation of adults variable, possibly due to sexual differences. Black spot or dusky blotch on or near margin between fourth and fifth dorsal spines, or two black spots on membrane between fourth and sixth dorsal spines and dusky blotches on membrane on ventral half of fin. Soft dorsal fin heavily spotted, pigmented, or opaque, but posterior dorsal ray always dark, and dark spot on body immediately behind ray. Membrane between posterior two anal rays sometimes pigmented, particularly in juveniles. Pectoral fin with black and white blotches as illustrated in Goode and Bean, 1896, pl. 112, Figs. 383, 383b; pectoral fin of juveniles has dark band with large black spot between fourth and eighth rays. Caudal fin has three dusky bands: wide band through caudal peduncle; narrow band intermediate on fin; and narrow dusky to black band on distal margin.

Sexual Dimorphism. Teague (1951, p. 37) noted that the specimens of *P. paralatus* from Texas (which he identified as *P. beani*) had prominent, squarish rostral exsertions that differed from those of the holotype of *P. beani*, which had broad, rounded contours. He stated "Never-the-less even this character may be nothing more than a variant. . . ."

Our examination of *P. beani* disclosed two distinctive types of rostral exsertions: (1) rounded, projecting, strongly serrated exsertions; and (2) flat, blunt, finely serrated exsertions. Seventeen specimens were examined to see if this morphological variation was sexual. Determination of the sex of large specimens on the basis of the shape of the rostral exsertions, was accomplished with considerable accuracy. Small specimens, however, had rostral exsertions that were intermediate in shape and one large female had the male form. The males had rounded, highly serrated, projecting exsertions while the female exsertions were finely serrated and blunt (Fig. 2).

TABLE 4

Distribution of tubercles on lower limb of second, third, and fourth gill arches of the *Prionotus alatus* species group

Species	Second Gill Arch							Third Gill Arch					Fourth Gill Arch					
	8	9	10	11	12	13	14	7	8	9	10	11	6	7	8	9	10	11
P. alatus	1	3	19	25	16	1	1	1	4	32	20	9		8	36	18	2	2
P. paralatus		6	13	20	5			1	10	22	9	2	1	19	17	6		
P. beani			12	39	22	9			11	47	22	2	2	16	42	17	4	

TABLE 5

Numbers and percentage of squamation ventrally by zones in the *Prionotus alatus* species group

Species	Chest Squamation Zones							
	1*		2†		3‡		4§	
	No.	%	No.	%	No.	%	No.	%
P. alatus	69	94.5	3	4.1	1	1.4		
P. paralatus	15	34.1	14	31.8	15	34.1		
P. beani			6	7.2	51	60.7	27	32.1

*Zone 1. Area posterior to a transverse line through base of innermost pelvic rays.

†Zone 2. Area between bases of innermost and outermost pelvic rays.

‡Zone 3. Areas between bases of outermost pelvic rays and anteriormost pectoral free ray.

§Zone 4. Area anterior to bases of anteriormost pectoral free ray.

Comparison and Relationship of Species in the *Alatus* Species Group

External characteristics have been used to distinguish and show the relationship of species within the *alatus* species group. Ginsburg (1950), pp. 522-523) used the length of the longest lower

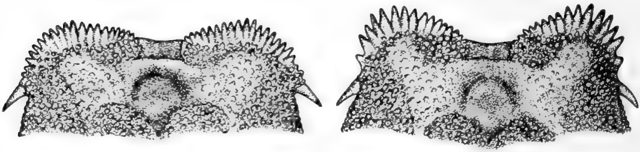

Fig. 2. Dorsal view of rostral exsertions of *Prionotus beani* showing sexual dimorphism. Left, female; right, male.

TABLE 6

Occurrence of nasal spines in the *Prionotus alatus* species group

Species	Number Examined	Nasal Spines			
		Present		Absent	
		Number	%	Number	%
P. alatus	110	109	99.1	1	0.9
P. paralatus	62	0	0.0	62	100.0
P. beani	81	19	23.5	62	76.5

joined pectoral rays and the extent of squamation ventrally for distinguishing the species. He also used the length of the longest upper joined pectoral rays, head length, eye width, and interorbital width, but noted that these characters overlapped considerably between species.

P. beani, *P. alatus*, and *P. paralatus* may be identified by one or a combination of the following characters: longest upper or lower joined pectoral rays; extent of squamation ventrally; preopercular spine length; and presence or absence of nasal spines. We found that head length, orbital width, orbital depth, interorbital width, pelvic length, and length of first, second, and third free pectoral rays when plotted were not diagnostic for the identification of these species.

P. beani and *P. paralatus* are similar in having the longest lower joined pectoral ray much shorter than that of *P. alatus* in specimens over 60 mm SL (Table 7, Fig. 3). Ontogenetic changes occur in the pectoral fin of individuals of all three species less than 60 mm SL. In *P. beani* and *P. paralatus*, the longest lower joined pectoral ray becomes proportionately shorter and more nearly equal in length to the longest upper joined pectoral ray; whereas, in *P. alatus* the longest lower joined pectoral ray remains proportionately as long as or may even become longer than the longest upper joined pectoral ray.

The similarity of *P. beani* and *P. paralatus* may be seen in the much shorter upper joined pectoral ray compared to the much longer ray in *P. alatus* in specimens greater than 60 mm SL. Some overlap did occur in this character between the species (Table 7, Fig. 4).

The strongly scaled chest and breast of *P. beani* differed considerably from the naked chest and breast of *P. alatus* (Table 5). *P. paralatus* is intermediate in chest squamation between *P. alatus* and *P. beani* (Table 5).

The long preopercular spines in the triglid specimens (*P. paralatus*) from Aransas Pass, Texas, were noted by Teague (1951, p. 37), who stated that they differed from the holotype of *P. beani*, but attributed the greater length to age. We are able to separate *P. beani* from *P. paralatus* greater than 60 mm SL, on the basis of the preopercular spine length (Table 7, Fig. 5). Preopercular spines of *P. paralatus* average 12.3 per cent SL, whereas *P. beani* spines

TABLE 7

Selected measurements of the *Prionotus alatus* species group expressed as ranges in percentage of standard length (SL)

	P. alatus		*P. paralatus*		*P. beani*	
	Range % SL	Mean % SL	Range % SL	Mean % SL	Range % SL	Mean % SL
Head length	35.2–41.8	38.4	35.6–41.8	41.1	35.2–43.1	39.4
Longest upper joined pectoral ray	35.9–62.4	46.2	36.4–45.1	40.8	30.7–49.4	39.0
Longest lower joined pectoral ray	53.7–80.7	67.4	36.3–56.5	43.5	33.5–55.6	43.5
First free ray pectoral L.	22.7–30.0	25.7	25.1–32.3	27.8	23.6–33.3	27.3
Second free pectoral L.	19.1–27.0	22.1	21.3–27.8	23.7	20.0–32.8	23.3
Third free pectoral L.	15.3–23.1	18.9	16.9–24.8	20.7	16.2–27.0	19.4
Pelvic L.	21.9–33.7	27.8	21.7–28.4	24.9	22.1–28.0	25.2
Preopercular spine L.	5.7–14.4	10.3	9.5–15.6	12.3	5.2–11.8	9.0

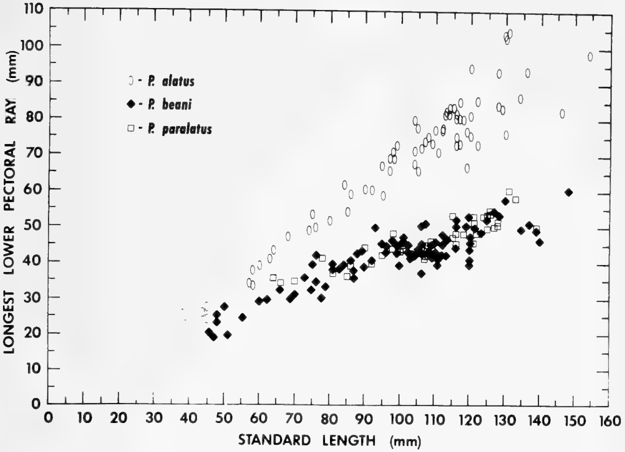

Fig. 3. Length of the longest lower joined pectoral ray in relation to standard length in the *Prionotus alatus* species group.

average only 9.0 per cent SL. *P. alatus* preopercular spines are intermediate in length (10.3 per cent SL), and overlap both *P. beani* and *P. paralatus* (Table 7).

The presence or absence of nasal spines separates both the juveniles and adults of *P. alatus* from *P. paralatus*. In *P. alatus* the nasal spines are present, in *P. paralatus* absent, and in *P. beani* the spines are present or absent (Table 6).

In view of the similar appearance of fins in juveniles of *P. beani* and *P. paralatus* to those of the juveniles and adults of *P. alatus*, it might be postulated that *P. alatus* is the most primitive species and similar in appearance to the progenitor of this species group.

DISTRIBUTION AND ECOLOGY

Prionotus beani is found on the continental shelf and slope from Panama to Brazil (Fig. 6). The species ranges in depths from 25-150 fathoms but is usually found in 30-70 fathoms. *P. beani* lives in the Southern Cool-Tropical subregion as defined by Miller (1969). The bottom water temperatures at nine stations where the species

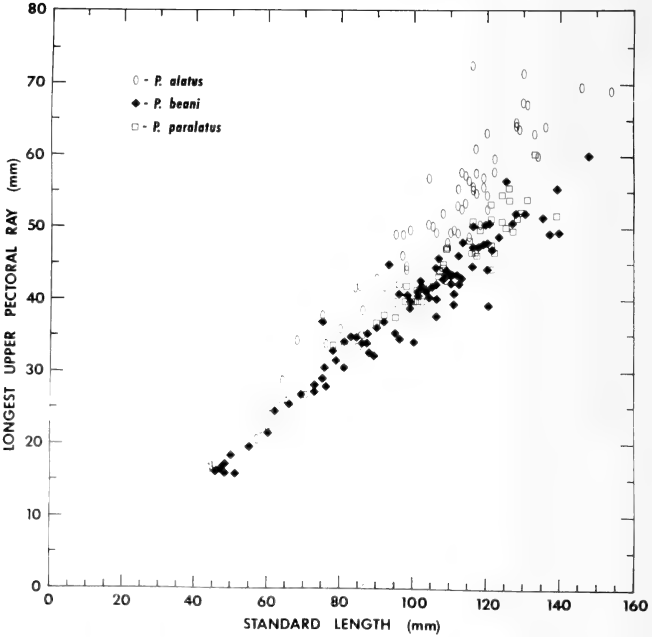

Fig. 4. Length of the longest upper joined pectoral ray in relation to standard length in the *Prionotus alatus* species group.

was collected ranged from 69-82 F. with a mean of 76 F. *P. beani,* like its geminate *P. paralatus,* is found on a sand or mud bottom. *P. beani* is a tropical species, allopatric with its warm-temperate cognates, *P. paralatus* and *P. alatus.*

P. paralatus is found on the continental shelf and slope in the western Gulf of Mexico from the Mississippi delta to the Gulf of Campeche. The species is known to range from 19-103 fathoms, but, like *P. beani,* is usually found on the outer shelf from 30-70 fathoms. *P. paralatus,* a member of the Northern Warm-Temperate fauna, inhabits waters of the subtropical zone, but it is also found in the Northern Cool-Tropical subregion (Miller, 1969). In winter,

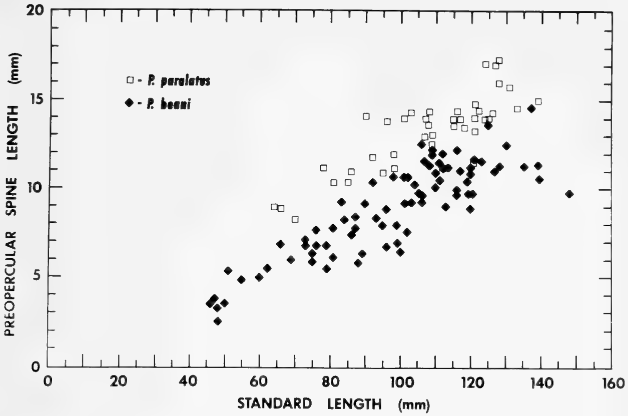

Fig. 5. Length of preopercular spine in relation to standard length of *Prionotus paralatus* and *P. beani*.

bottom temperatures where *P. paralatus* is found are generally less than 64 F (18 C). *P. paralatus* is sympatric with *P. alatus* only in the region of the Mississippi delta.

P. alatus is found on the continental shelf and slope in the Atlantic Ocean and Gulf of Mexico from Virginia to Louisiana, and on the Campeche Bank, and the Greater Bahama Banks (Fig. 6). The species occurs at depths from 30-250 fathoms, but, like its cognates, is usually found in 30-70 fathoms. *P. alatus*, like *P. paralatus*, is found primarily in the Northern Warm-Temperate region in the subtropical zone. Bottom water temperatures ranged from 51-67 F, averaging 61 F, at five stations where *P. alatus* was captured. Unlike its cognates, *P. alatus* occurs over a calcareous shell-sand bottom.

The distribution of the *alatus* species group raises the following questions: Why do *P. alatus* and *P. paralatus*, warm-temperate species, occur in the tropical region of the southern Gulf of Mexico? Why are so many wide-ranging, coastal, tropical South American species, with distributions as far north as Honduras and British Honduras, missing from the Gulf of Mexico? Why are the cognate species *P. beani* and *P. paralatus* allopatric when their depth dis-

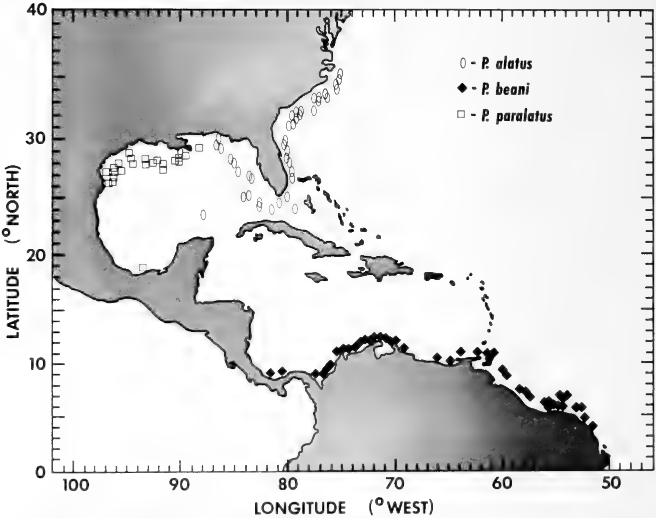

Fig. 6. Distribution of the *Prionotus alatus* species group in the western Atlantic Ocean.

tributions and bottom habitats are similar and the distance separating the species is within easy range of migration, random movement, or larval drift?

Bottom water temperatures of the southern Gulf of Mexico were scrutinized for a possible explanation. Warm-temperate fishes are able to survive on the Campeche Banks at depths greater than 20 fathoms, while true tropical fishes cannot exist there because upwelled cold water, inundates the Campeche Bank during late spring and summer (Cochrane, 1966; Springer and Bullis, 1956).

Tropical fishes (minimum temperature tolerance of 18 C) are not able to survive as adults in the northern Gulf of Mexico and along the South Atlantic coast of the United States (Northern Warm-Temperate region of Miller, 1969), except in the tropical Florida Keys-Tortugas Bank subregion. Bottom temperatures in this region decrease well below 20 C during the fall, winter and spring seasons (Thompson, 1966; Springer and Bullis, 1956; Bullis and Thompson, 1965; Walford and Wicklund, 1968; and Taylor and Stewart, 1959). A fauna associated with reefs deeper than 15

TABLE 8

Selected measurements of the *Prionotus alatus* species group expressed as ranges in percentage of head length (HL)

	P. alatus		*P. paralatus*		*P. beani*	
	Range % HL	Mean % HL	Range % HL	Mean % HL	Range % HL	Mean % HL
Orbital width	20.0–26.2	23.8	21.7–28.2	25.1	21.0–29.5	24.1
Orbital depth	19.3–28.3	23.6	19.2–26.4	23.1	18.7–27.1	22.5
Interorbital width	9.1–13.5	11.0	8.8–12.7	10.4	9.3–13.6	12.1

fathoms in the Northern Warm-Temperate region is not tropical but consists of species with warm-temperate tolerances ($<$20 C).

COMMENTS

Merulinus salmonicolor (Fowler, 1903) was placed in the synonymy of *Prionotus alatus* by Ginsburg (1950, p. 524), based on the original description. However, Teague (1951, pp. 47-48) retained *P. salmonicolor* (Fowler) as a valid species. I have consulted an unpublished manuscript by Ginsburg entitled "Comparison of two recent reviews of western Atlantic triglid fishes with additional information on the species," which is deposited in the files of the Division of Fishes of the USNM. In this manuscript Ginsburg states that he had examined the holotype of *P. salmonicolor* and found that it was not a junior synonym of *P. alatus*; and that *P. pectoralis* Nichols and Breder, and *P. vanderbilti* Teague, were examined and are junior synonyms of *P. salmonicolor*. The senior author of the present paper examined the holotype of *P. salmonicolor* (ANSP 24343) in the ANSP collections and concurs with Ginsburg. The *salmonicolor* species group is poorly understood and is presently being reviewed by the senior author and Donald Miller.

SPECIMENS EXAMINED

Prionotus beani. Holotype. USNM 39318, 1 (110 mm. SL). *Other Specimens.* TABL: 103432, 1 (130); 103433, 1 (86); 103434, 2 (73-75); 103435, 4 (75-106); 103436, 6 (88-102); 103437, 1 (48); 103438, 1 (48); 103439, 1 (106); 103440, 1 (107); 103441, 2 (50-99); 103406, 5 (47-116); 103442, 3 (98-146); 103443, 4 (128-148); 103444, 1 (123); 103445, 2 (120-121); 103446, 2 (73-120); 103447, 1 (98); 103448, 4 (51-101); 103449, 5 (79-120); 103407, 1 (139); 103450, 2 (96-99); 103451, 4 (47-101); 103452, 2 (78-81); 103453, 2 (83-110); 103454, 17 (76-120); 103456, 1 (109); 103457, 2 (102-106); 103458, 1 (104); 103459, 3 (93-116); 103460, 1 (62)) USNM: 39318, 1 (110); 183400, 4 (114-135); 185166, 1 (130) 185185, 1 (120); 185125, 1 (105); 185129, 2 (41-49); 185140, 2 (45-46); 185131, 6 (55-63); 185139, 6 (53-66); 185219, 12 (43-73); 185120, 3 (76-94); 185136, 1 (107); 185115, 1 (84); 185397, 4 (50-144); 185414, 7 (100-127).

Prionotus paralatus. Holotype. USNM 151939, 1 (158). *Paratypes.* USNM: 10472, 2 (77-90); 155071, 1 (87); 155072, 2 (111-112); 155073, 4 (81-104). *Other Specimens.* TABL. 103461, 1 (139); 103462, 1 (90); 103463, 1 (64); 103464, 3 (115-128); 103395, 1 (108); 103408, 1 (124); 103396, 2 (78-121); 103397, 2 (124-128); 103398, 1 (92); 103399, 3 (107-

125); 103400, 1 (85); 103401, 3 (101-115); 103404, 2 (116-127); 103402, 1 (109); 103403, 3 (121-131); 107403, 1 (118); 107402, 1 (81); 107406, 1 (126); 107410, 2 (116-126); 107408, 1 (121); 107411, 1 (133); 107407, 2 (95-98); 107401, 6 (100-108); 107412, 1 (70); 107409, 1 (107); 107404, 1 (98); 107405, 3 (66-117). USNM: 196771, 1 (112); 157669, 5 (98-135); 157529, 11 (83-145), 185127, 2 (75-81); 158289, 4(43-56); 151939, 1 (124); 158257, 1 (43).

Prionotus alatus. Other Specimens. TABL: 103413, 3 (39-64); 103414, 3 (57-104); 103415, 1 (146); 103416, 1 (123); 103417, 9 (60-136); 103418, 2 (97-122); 103391, 1 (95); 103419, 1 (133); 103420, 1 (112); 103421, 1 (119); 103422, 2 (38-45); 103423, 7 (108-120); 103424, 1 (110); 103425, 1 (130); 103426, 20 (90-119); 103427, 1 (58); 103428, 4 (85-134); 103429, 2 (107-120); 103392, 2 (80-86); 103393, 1 (74); 103430, 3 (92-129); 103431, 1 (154); 103394, 1 (113). USNM: 131493, 1 (107); 43582, 2 (136-138); 151933, 1 (80); 151963, 4 (88-130); 460, 1 (79); 152078, 1 (124); 46016, 1 (142); 157688, 2 (118-148); 161361, 1 (107); 157406, 2 (56-59); 117266, 7 (74-110); 92054, 4 (58-72); 117171, 1 (99); 158268, 3 (76-107); 158322 1 (128); 158267, 1 (138); 157530, 1 (137); 157687, 2 (110-138); 163508, 5 (99-127); 46017, 4 (93-135); 43582, 2 (136-138); 157407, 1 (126); 103394, 1 (113).

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Pollution in Areas near the Pompano Beach Sewage Outfall

Harrison A. Hoffmann

This paper reports the results of studies designed to determine whether a sewerage outfall contributes to the pollution of adjacent beaches. The methods employed were limited to a study of the currents and to examination of the water for coliforms in the areas of the sewerage outfall, the Hillsboro Inlet and adjacent beaches located in the city of Pompano Beach, Florida.

Pearson (1965) reviewed the literature to 1955 and developed mathematical formulae for the prediction of the rate of dilution and diffusion of sewage in the area of a marine outfall. More recent investigations reported by Garber (1960), the Alan Hancock Foundation (1965) and Saville (1966) have employed chemical analyses, dye-plume studies and coliform counts to determine the fate of organic wastes discharged into a marine environment.

The physical features of the area studied are shown in Nautical Chart 845 SC which is reproduced in part in Fig. 1. The outfall line extends east approximately 2500 yards from the shore line and approximately 3400 yards southeast of the Hillsboro Inlet. The proximity of the Hillsboro Inlet complicates the interpretation of data since polluted water from the Intracoastal Canal usually flows south along the beach during an outgoing tide. This mixing of waters from two sources of pollution requires an extrapolation of data to determine the probable extent of pollution from the outfall.

The outfall pipe has an inside diameter of 30 inches and the terminal outlet is inclined approximately 22° from the ocean floor. The vertical distance from the outlet to the surface of the water is approximately 87 feet.

Sewage and sludge receive a primary treatment of comminution, removal of floatables, and chlorination to reduce odor. The current volume of sewage is approximately 2.2 million gallons per day with the highest flow rates occurring between 0900-1100. Sewage sludge which settles to the bottom of the holding tanks is dumped through the outfall daily between the hours 0900-1200. The mean flow rate during the peak pumping time is estimated at 3000 gallons per minute.

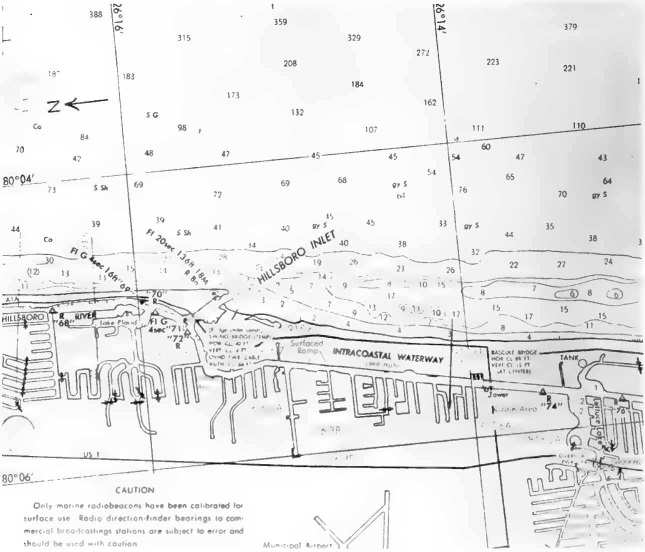

Fig. 1. Section of Nautical Chart 8575C (1965) showing location of Pompano Beach Outfall.

PROCEDURES AND METHODS

All samples used in this investigation were collected during the morning hours from 0900-1100 for the period extending between December 1966 and September 1967. Surface samples were collected in sterile wide mouth bottles with screw caps. Deep samples were taken with a Bacteriological Water Sampler (CM^2, Inc., Mt. View, California). Collection of samples and subsequent examination followed procedures as recommended in Standard Methods (American Public Health Association, 1962). All samples were held in ice until used in the laboratory. No samples were held longer than four hours. The membrane filter (Millipore) was employed with m Endo Broth MF for measurement of the coliform group. A small number of samples were examined for fecal coliforms using the procedures and FC Medium described by Geldreich

TABLE 1
Summary of oceanographic conditions and appearance of boil near outfall

Number and Date	Surface Boil	Sea Condition	Wind (from) Direction	Wind (from) Speed	Current (toward) Speed	Current (toward) Depth	Current (toward) Direction
12/22/66	+	calm	NNW	4	0.4	50	SSE
12/29/66	+	calm	SE	6	0	50	
1/26/67	+	3–4 ft	SE	10	0.3	50	ENE
2/ 2/67	+	1–3 ft	ESE	8	0.3	50	N
2/19/67	+	calm	SSE	1	0.5	10	N
					0.3	20	N
					0.1	50	N
2/21/67	+	1–3 ft	S	2	—	12	SSE
3/ 9/67	+	1–3 ft	SE	8	0.3	12	WSW
3/16/67	+	4–5 ft	NW	18	0.6	12	N
4/ 6/67	+	1–2 ft	SE	5	0.6	12	N
4/20/67	+	2–3 ft	NE	10	0.3	12	SSW
4/25/67	+	calm	NE	3	0.6	12	S
5/10/67	+	calm	calm	0	1.5	12	N
5/24/67	—	calm	SW	3	1.0	12	N
5/26/67	+	calm	SW	3	0.6	12	SW
5/31/67	+	calm	SW	6	0.2	12	SSW
6/ 2/67	—	2–3ft	NE	10	1.3	12	SSW
6/ 7/67	—	0–1 ft	SE	5	0.4	12	NE
6/ 9/67	—	calm	S	2	0.9	12	SW
					0	60	SW
6/16/67	—	1–3 ft	SSW	4	0.5	12	NE
6/22/67	—	calm	NNE	2	0.9	12	NE
6/27/67	—	3–4 ft	S	12	1.0	12	NE
					0.7	60	N
					0.6	80	N
6/29/67	—	1–2 ft	SSW	4	1.2	12	N
7/18/67	+	4–6 ft	SSE	18	0.6	12	NNW (0900 EDT)
7/18/67	+	2–4 ft	ESE	12	0.3	12	WSW (1100 EDT)
7/20/67	—	4–5 ft	ENE	15	1.2	12	NNW
7/25/67	+	4–5 ft	SE	15	0.5	12	NNW
7/27/67	—	2–3 ft	SSE	8	2.0	12	SW
8/ 1/67	—	calm	NNE	3	1.2	12	N
8/ 3/67	—	3–4 ft	SSE	10	1.1	12	NE
8/ 9/67	—	1–2 ft	SE	4	0.7	12	SW
8/12/67	—	3–5 ft	S	15	1.8	12	N
8/14/67	+	calm	N	2	0.8	12	N
8/16/67	+	2–3 ft	NE	8	0.7	12	N
8/21/67	+	3–4 ft	SE	15	0.5	12	S
8/23/67	—	2–5 ft	E	10–18	0.8	12	N

\+ = boil visible
— = boil not visible

et al. (1965). Unless otherwise indicated, all counts are given as coliforms.

Direction and velocity of currents were determined with current crosses usually set at a depth of twelve feet. Positions were determined by taking cross-bearings with an Ilon Position Finder. Calculated precision of the positions is ±25 yards in relatively calm seas to ±50 yards in rough seas.

OBSERVATIONS AND RESULTS

Currents at the Outfall Site. Table 1 summarizes the observed oceanographic conditions in the area of the outfall during the times samples were collected. The presence or absence of a boil at the surface generally can be correlated to the velocity of the current. With two exceptions, the boil was always present with current velocities below 0.7 knots and always absent with current velocities above 0.8 knots. No correlation with the direction of the current was noted.

During an ebbing tide, water from the Hillsboro Inlet usually

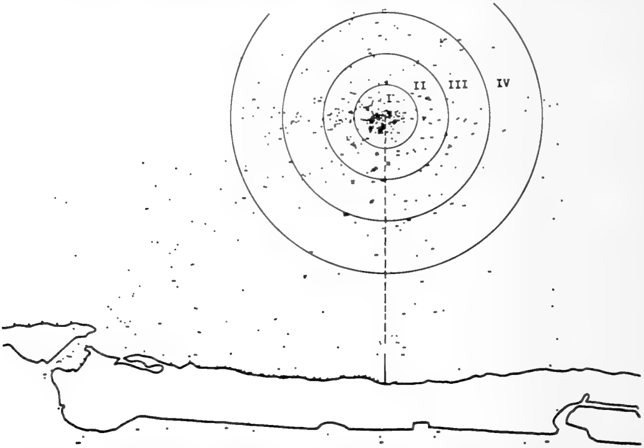

Fig. 2. Approximate location of each sample collected: Zone 1, 0-300 yards; Zone 2, 300-600 yards; Zone 3, 600-1000 yards; Zone 4, 1000-1500 yards from the outfall.

moved south as a littoral current, and less frequently moved southeasterly toward the outfall. On one occasion at low slack tide, brown, turbid water from the Intracoastal Canal had moved southeast to a point only 600 yards from the outfall.

Bacteriologic Analysis at the Outfall. During the early phases of this study, samples were collected near the surface and at varying depths. At locations near the boil, surface samples usually gave a higher coliform count than samples collected at depths of 20 and 50 feet. In areas distant from the boil no significant differences in counts could be related to varying depths. Subsequently, most samples were collected at approximately one foot below the surface of the water.

Figure 2 shows the approximate points of collection for most of the samples tested. These points of collection do not show a random distribution since the primary objective was to determine the maximum pollution near the outfall and the dilution rate in terms of the distance required for the reduction of this pollution. The areas around the outfall have been separated into four zones for convenience of reference and analysis of data. These zones were established after all samples were taken. Although zones of equal area or a larger number of zones would provide more points for graphic analysis, this arrangement does not provide an adequate number of samples for evaluation in each area.

TABLE 2
Summary of coliform counts per 100 ml in zones around the outfall

Areas	Boil	Zone 1* 0–300 yds	Zone 2 300–600 yds	Zone 3 600–1000 yds	Zone 4 1000–1500 yds
Maximum	390,000	390,000	202,000	9,300	584*
Mean	81,000	19,430	6,292	337	48**
Median	61,000	300	37	16	19
Minimum	3,000	0	0	0	0
Number of Samples	21	126	92	73	52
% Samples above $10^3/10^2$ ml	100	42	21	5	2

*Zone 1 inclues samples in boil
**Values obtained by excluding a single high count of 7,400

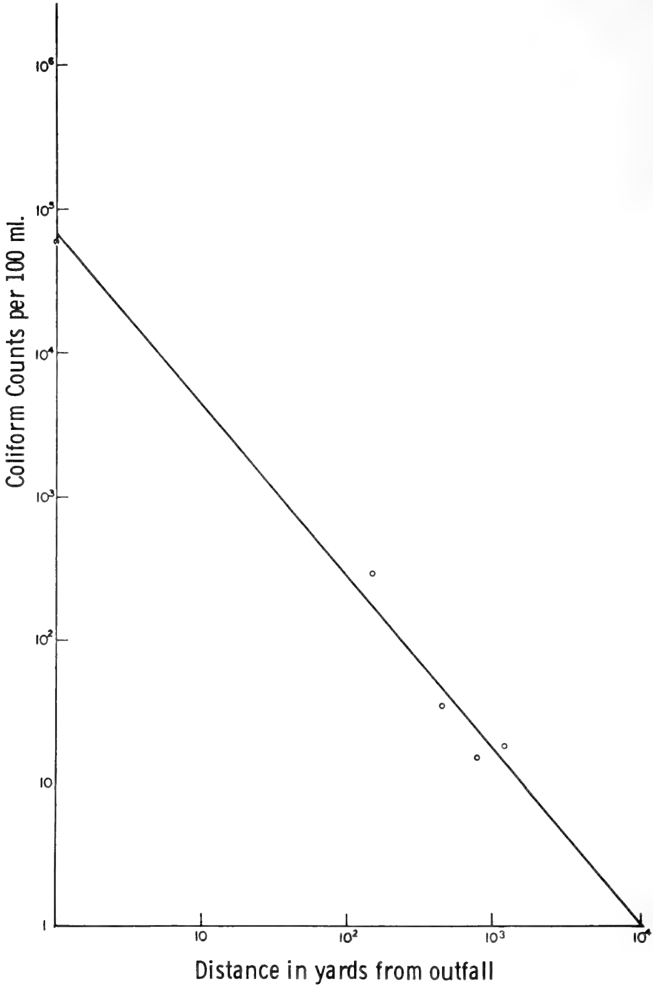

Fig. 3. Mean coliform counts plotted against mean zone distance from the outfall (semi-log transformation).

A summary of the coliform counts of the samples in each area is given in Table 2. Samples from intracoastal waters encroaching from the Hillsboro Inlet, as determined by turbidity and color, are excluded from these data. The wide differences between mean values and median values in all zones are characteristic of pollution by particulate material and indicate the non-uniform distribution and slow mixing of the sewage with the surrounding water. These differences decrease with distance from the outfall.

When logarithms of the mean values are plotted against the arithmetic median distance of each zone, the points approximate a straight-line curve as shown in Fig. 3. The slope of this curve represents an approximate logarithmic reduction in counts with increasing distance from the outfall. Since the decrease in coliform counts with distance from the source of pollution is effected by both dilution and rate of death, the term *decimal reduction distance* is used here to denote the distance required to reduce the coliform count by a factor of 10 (90 per cent). On the curve for the mean values, the decimal reduction distance is approximately 400 yards. A semi-log transformation of the percentage of samples showing counts above 1000 per 100 ml also gives a straight-line correlation.

The median values listed in Table 2 are not amenable to semi-logarithmic correlation as is the case with the mean counts. The points for median counts approximate a straight line when both variables are plotted as logarithms as shown in Fig. 4.

An analysis of the data summarized in Table 2 by the method of multiple regression shows a high degree of inverse correlation between coliform counts and distance from the boil ($R^2 = 0.98$).

The two sets of data lead to different conclusions. Extrapolation of the mean values show mean coliform counts approaching zero at approximately 1800 yards from the outfall, while a similar extrapolation of median values indicate that median coliform counts of 7 per 100 ml would be found at the beach, 2500 yards from the outfall. Analyses of frequency distribution of the coliform counts show that maximum frequency is weighted sharply toward lower values. This type of distribution gives greater validity to median values. Interpretations of single-source diffusion data obtained by other workers (Alan Hancock Foundation, 1965; Brooks, 1960) suggest that the data of median correlations would be the more reliable of the two sets of data.

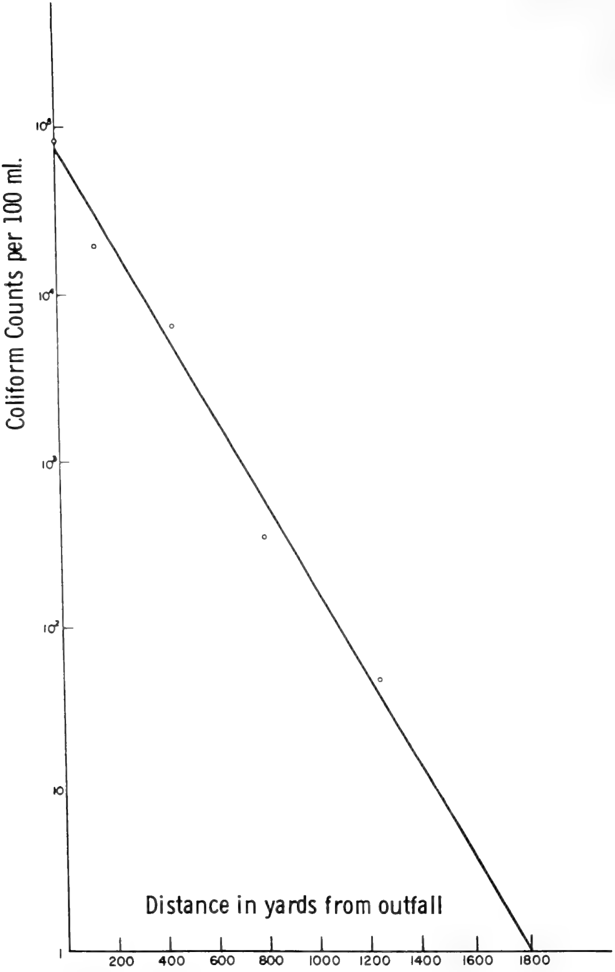

Fig. 4. Median coliform counts plotted against mean distance from the outfall (log-log transformation).

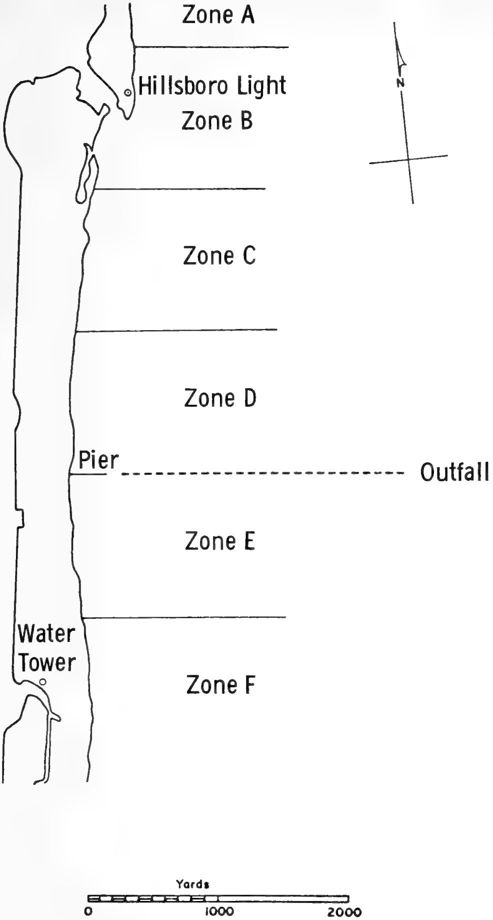

Fig. 5. Location of zones established for off-shore sampling (use with Table 3).

Bacteriologic Analysis of Beach Areas and Intracoastal Water. Samples were collected along transects perpendicular to the beach

TABLE 3

Coliform counts per 100 ml in samples on Transects from Beach to 1800 yards seaward. (Use with Fig. 5)

Tide	Zone (Fig. 3)	Distance in Yards From Beach: 100	300	400	600	800	1000	1200	1400	1600	1800
R 5 hrs	A	9			7			9			1
R 4 hrs	B			40			280			126	
F 5 hrs	B		16,000	9000		8000				3300	
F 1 hr	C	173	109		32					18	
		30	246		24					51	
F 1 hr	C		100							8	
F 5 hrs	C					1	6			33	
			64			23					
R 5 hrs	C	200	12			50					
R 5 hrs	D		100				1		0		
		1100	21	88			9			2	
F 3 hrs	D	1700									
R 4 hrs	E			1670		1400		584	665		16
				284*							
F 5 hrs	E			303*			252*			248*	93*
				321*							
F 5 hrs	E	15			11				10		
R 4 hrs	F	1600				700				452	

*Used FG Medium (Difco); counts represent fecal coli.

R, rising.
F, falling.

TABLE 4
Coliform counts per 100 ml from samples in the Intracoastal Canal and Pompano Beach (Hillsboro Inlet Areas)

Location	Canal	Beach*
Maximum	150,000	6000
Mean	12,900	1931
Median	2,300	500
Minimum	200	0
Number of Samples	20	26
% above $10^3/10^2$ ml	70	40

*Three samples showing TNTC at 1:1000 dilution not used in these data.

from 100 yards-1800 yards off-shore. For convenience, the areas of sampling are represented as zones shown in Fig. 5 which should be used for evaluation of the data in Table 3. In general, the coliform counts along these transects decreased with an increase of distance from the shore.

A summary of coliform counts from swimming areas along the beach between the Municipal Pier and the Hillsboro Inlet, and in Intracoastal waters are shown in Table 4. The counts in these areas show relatively heavy pollution.

A review of all the data leads to the conclusion that coliform counts decrease with the distance from the outfall, but, at a variable point approaching the shore, counts increase to a relatively high level. Although it is probable that the sewage outfall contributes small numbers of coliforms to the beach area, most of the indicated pollution on the beach probably comes from the Intracoastal Canal.

It is possible that levels of pollution in waters near the beach would be significantly higher than those predicted from extrapolation of the data. Brooks (1960) in his discussion of coefficient of diffusion curves, states that coliform counts may be increased to three-fold near the shore due to upwelling of bottom water and decreased flushing in shallow water. The location of a reef 600 yards off shore and west of the Pompano Beach outfall would probably accentuate this process of entrapment and concentration.

Discussion

Coliform bacteria have a relatively short survival time in sea-

water as compared to fresh water. Reports in the literature show little agreement in the death rate of coliforms in seawater. Depending upon the experimental conditions and the strains of bacteria used, reported decimal reduction times vary from 3 hours-23 days (Carlucci and Pramer, 1960; Orlob, 1956). Studies in our laboratories (unpublished) of the survival times of coliforms in sewage-seawater mixtures show a decimal-reduction time of approximately 10 hours. In both aged seawater and sewage-seawater mixtures, *Enterobacter aerogenes* survives longer than *Escherichia coli.*

Coliform bacteria are not indigenous to marine waters and usually can be found only in those marine areas adjacent to sewage outfalls, estuaries, or marinas. Although the presence of coliforms in marine waters is good evidence of pollution by sewage, the absence of these bacteria can not be construed as evidence of safe water. The prolonged survival of viruses in seawater (Liu, et al., 1966) and their low infective dose (Plotkin and Katz, 1966) suggest that these agents must serve as the ultimate indicators of pollution with respect to health and sanitation.

Although every effort was made to maintain a separation of samples between inlet waters and sewage outfall waters by clearly discernible color differences, it seems probable that there is some mixing of these waters during tidal cycles which might have contributed some error to the outfall data.

Visual observation and the distribution of coliform counts indicate that there is a major dilution and dispersion of the sewage in the turbulence of cross-currents at the outfall. The stream of sewage frequently breaks up into pockets which become stabilized in prevailing current. Additional dilution appears to be slow except when additional eddies are formed. The current data given in this report have been confirmed and expanded by the more recent work of Lee (1969). He shows that the western edge of the Florida Current ranges from near shore to more than three miles sea-ward. He also describes large eddies which spin off from the western edge of the Florida Current and move counterclockwise toward the shore, south along the shore and ultimately back to the prevailing northerly stream.

Where these eddies contact the sewage plumes, additional dispersion and diversion of the sewage would occur. When these

eddies do not divert the sewage plumes, they move for miles in the prevailing northerly current. On one occasion, counts ranging from 150-650 coliforms per 100 ml were found in a series of five samples collected eight miles north of the sewage outfall.

These observations and experimental data strongly indicate that low concentrations of sewage do reach surfing and swimming areas within two miles of the marine outfall at Pompano Beach. Conclusive evidence relative to the public health significance of these findings must await the development of better methods for utilizing viruses or other bacterial species as indicators of pollution.

The extension of existing and planned sewage outfall lines to terminate at the maximal western edge of the Florida Current would probably insure safe waters for recreational use. However, the continued use of marina outfalls for short-term economic disposal of sewage does not eliminate the loss of fresh water and potential fertilizer which will become increasingly needed resources if population densities are not stabilized at a rational ecological level.

SUMMARY

Studies are described which attempt to predict the extent of pollution from a marine sewage outfall in a location where the affected areas are subject to possible pollution from a second source. The data obtained from coliform counts combined with measurements of the Florida Current strongly indicate that existing and planned marine outfalls on the southeast coast of Florida do and will contribute low levels of pollution to off-shore and beach waters. The significance of these findings is discussed.

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